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The Necessity of a Changing World

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As we follow the trends in the world of science from year to year, we scarcely realize the progress being made or the changes taking place. We read of new discoveries, listen to reports of progress, and see gradual changes here and there, but perhaps they make little impression. It is only when we see the progress in spans of 5, 10 or possibly 20 years that we begin to realize the changes taking place and the advances being made. Such a situation applies to entomology perhaps more than to most of the other sciences.

In our annual gatherings in the past we have listened to statements by eminent authorities extolling the achievements of insects and emphasizing the present as the age of insects. Such statements have been definitely worth while in arousing mankind to a real danger and perhaps a potential catastrophe. And yet, when we recall that the science of applied entomology is scarcely more than 60 or 70 years old and note the progress in insect control during that time, we realize at once that man is gaining the upper hand. Well may we anticipate the time when chemical, electrical and mechanical warfare; insect-resistant varieties of plants and breeds of animals; and our farm and home practices, together with the aid of insects' natural enemies, will reduce insect control to a routine, just as the medical profession has reduced or practically eliminated certain diseases which were once responsible for the loss of thousands of human lives. But we must not be too optimistic, for without the continuation and enlargement of research, together with effective teaching and extension work, we may well predict a victory for the insects.

The Need of Continuous Research.—With the foregoing premise, perhaps we should first show the need for a continuation and enlargement of entomological research by reviewing the history of past problems. In looking back—and I intend to look back only so far as the past may enlighten our course for the future—we see notable achievements in insect control which have faded into insignificance because of changed conditions or factors for which man, in his changing moods, has been responsible. Perhaps a few examples will clarify our thoughts and explain why some insect problems may require many years of research and, even when essentially solved, should be followed with further research, just as medical problems are continually requiring newer or better or cheaper or more practical methods of dealing with ailments seemingly conquered.

The peach tree borer is an insect which has been a recognized primary pest of the peach tree from the earliest colonial days and one which has received much attention and study. Dozens of remedies were suggested and hundreds of chemical treatments tested, but nothing sufficed, excepting the laborious and unsatisfactory method of hand worming, until about 1920 when the almost perfect method of control with paradichlorobenzene was discovered. This is a case where continuous and persevering research over a period of more than half a century finally produced a reward which many times repaid all the costs of the research of the past. But even in the case of the peach tree borer, for which we now have an almost ideal insecticide, some workers are continuing their research to secure even better results, that is, safer, more effective, cheaper, simpler and more practical methods, that may be applicable under every conceivable condition which may develop.

An insect which occurs throughout the greater part of North America, and which has had an existence of major importance for many years, is the codling moth. When seeking support for codling moth research we are invariably questioned regarding the need of continual research on a problem which is as old as the apple industry and one which has received much attention from entomologists. Doubtless all who have maintained codling moth, or other long-time research projects, have been similarly questioned when seeking funds for continuation of such projects, especially those which have existed five or more years. But if we analyze each of these situations it is not difficult to show that we are not duplicating work year after year or failing to make reasonable progress, that the necessity for continued studies does not arise from the fact that we have found no solution; but that we are forced to continue research on major problems year after year because, with changing social, economic, legal and perhaps political situations, solutions for an insect problem that are all right one day may be quite the opposite in the near future.

Thus, in the history of codling moth investigations, there have been a number of stopping places where the research work could have been discontinued but for changed conditions, which made continuation of research not only desirable but imperative. In the early history of the codling moth problem, banding seemed to be the only control necessary, and later when arsenicals, especially lead arsenate, were introduced and orchard spraying equipment made available, one insecticide application, or two at the most, was sufficient to be fairly effective and to provide satisfactory control of this pest. The intensive growing of apples in favorable localities further increased the difficulties of the fruit grower, but perhaps the greatest impetus to more nearly complete control of the codling moth was the attitude of the public, for there came a time when buyers were willing to pay a price profitable to the grower only when the fruit was free from worm infestation. At about the same time grading standards, probably the result of public demand, emphasized the importance of worm-free fruits. Furthermore, in some regions where arsenicals have been used consistently, a greater percentage of the worms which had a resistance or tolerance to arsenic survived, again increasing the difficulties of the grower. All of these factors led to the necessity of more frequent and heavier applications of insecticides and the use of spreaders and stickers. Codling moth control had reached a high degree of effectiveness when the residue problem appeared in the picture and it became necessary to reverse the process and attempt to develop means of removing spray residue, intensify investigations to secure effective insecticides non-poisonous to humans to replace lead arsenate—the otherwise almost ideal stomach poison—to utilize means, other than chemical sprays, which we may call supplementary practices, and to better time our insecticide applications to minimize residue, reduce cost and secure more nearly complete control, especially of the first brood of worms.

Investigations on the use of fluorine compounds were at least temporarily halted by a tolerance placed on fluorine similar to the tolerance placed on lead and arsenic by the federal Food and Drug Administration. Fruit washing methods to remove spray residues have reached a high degree of perfection, but in general are practical only for the larger growers. Heavy and more frequent spray applications to destroy almost completely the first brood of worms have made it possible to cut down on later sprays, thus minimizing the residue problem. Progress has been made in the development of so-called non-poisonous sprays, especially in the case of the fixed nicotines, but certainly much more research must be done before a practical non-poisonous material will be available for the fruit grower in most fruit growing localities. Supplementary practices show marked value, and growers are already recognizing their use in actual practice. Much has been done to solve the codling moth problem, in spite of conditions and situations which seem to be continually changing, but because of these constant changes there has been scarcely a year or period of years, when we could consider the problem solved from the standpoint of the commercial fruit grower, and so with these constantly changing conditions, continued study becomes a necessity.

The European corn borer is a good example to illustrate the changes which

may attend the control of an introduced insect. Its sudden appearance and conspicuous destructiveness, especially in Canada, aroused the public to the need for immediate action, but the problem was overplayed by demanding and securing the enormous sum of $10,000,000 from the federal government in an attempt at extermination. The failure of this costly experiment, which was anticipated by most entomologists, had a dampening effect on efforts to secure appropriations for much needed research. Fortunately, it was possible to continue research studies on a moderate scale even though the borer did no appreciable commercial damage in the states of the Central West previous to 1938. The effectiveness of complete coverage of corn stalks and the development of plow shields to accomplish this operation; the results obtained with time and rate of planting studies to reduce destructive borer populations; and the achievements in the development of hybrids and strains of corn resistant or tolerant to the borer were accomplishments resulting from this continuous research which warranted reducing corn borer investigation activities. Although not maintaining intensive research, entomologists have continued observations on borer trends from year to year, as already stated, and thus have traced conditions responsible for increase and decrease of spread and borer population and have followed the gradual transition to a two-brooded form as it moves southward, which is changing the situation completely so far as several of the control recommendations are concerned. These changes warrant reestablishing intensive research. Had we not maintained our observations and close contact with the corn borer over the past five or six years, during a period when the borer has not been conspicuous and has been forgotten so far as the public in the Central West was concerned, the changes which we have been able to follow would have materialized without our knowledge and would have presented a serious handicap for a continuation of research and extension. Certainly the small investment in following the borer trend has been insurance which has given large returns, more perhaps than we can ever evaluate.

Past experiences have demonstrated the danger which may result when lack of financial support interrupts insect studies, especially in the case of imported species. The discontinuance of appropriations for gypsy moth studies at a critical time is an excellent illustration. The necessity of uninterrupted studies over periods of years could be shown for perhaps all our principal insect pests, for certainly there are few if any insects responsible for major losses the control for which is so nearly complete and practical that further research is without profit. In fact, perhaps never, until an insect is essentially exterminated, will this situation exist.

CAUSES FOR A CHANGING STATUS OF INSECTS AND INSECT PROBLEMS.—No insect is a static thing and no insect problem remains the same indefinitely year after year. Instead, each problem may be modified by changes in intensiveness of cropping, in cultural practices and in the varieties grown; through legislative and regulatory requirements; through changes in the demands of the consuming public; through changed and changing environmental conditions; and even by changes in the insect itself. We need only examine any one of the crop pest treatises 10 years after its publication to realize the many changes in control recommendations that have occurred during even that short period of time.

Here again a few examples familiar to all entomologists will remind us of the numerous factors responsible for the changed status of many insects and what we may anticipate for others in the relatively near future in this rapidly changing world. Native insects struggling for a meager existence on hosts which are themselves struggling for existence have found a "land of plenty" on introduced, cultivated, related plants and have become serious handicaps to plants theretofore relatively free from insect attack. The worn-out example of the Colorado potato beetle is perhaps best known, although many others might be mentioned, and we might go so far as to state that all insects feeding on wild hosts are potential future pests of cultivated plants.

As already indicated, changes in cropping systems or agricultural practices have resulted in "new" problems. For example, in northern Indiana, the acreages removed from cultivation, resulting in idle land allowed to grow up in weeds, have become breeding places for millions

of tarnished plant bugs, and incidentally a favorable breeding and hibernating place for other insects. As the weeds mature and become less favorable for insect feeding, the bugs migrate to celery and potato fields, causing huge losses. Not only that but the insects are mature and very active, making the problem of control with insecticides practically impossible.

We know also of insects which transfer their activities to valuable property because of civilization activities. In this case we are thinking particularly of the termite, one of the nation's most destructive insects, although before the present modern civilization an insect which was beneficial, in that it lived in timbered areas and returned to the soil in the form of useful material dead woody plants. Strip farming, planting of shelter belts, reforestation of marginal land, introduction of new varieties of plants and breeds of animals, erosion control and a host of other agricultural activities, introduced with no consideration of their relation to insects, all play a significant part in our changing insect problems. An example or two may be appropriate.

In the reforestation program, extensive pine plantings have been made in the North Central states, resulting in the introduction and rapid spread of the pine shoot moth. Perhaps this could have been prevented had those promoting this project realized the insect factor and planned the project with the cooperation and advice of forest entomologists.

Again, we might refer to the conflicting viewpoints of wildlife enthusiasts, interested from the sportsman's standpoint, and persons interested in mosquito control from the standpoint of human health and comfort. Thus, we find the creation of numerous wildlife refuges close to the habitations of man. These and other projects resulting in the impounding of water have produced conditions favorable to the breeding of mosquitoes. On the other hand, much of the mosquito control work of the past few years has been unfavorable to wildlife. To accomplish the degree of mosquito control expected by the public, particularly in resort areas, and at the same time protect the breeding and feeding places of wild fowl, challenges the entomologist and the wildlife conservationist to develop new or modify old methods of procedure to serve both of these important purposes. Fortunately the changing public attitude, recognizing the necessity of mosquito control on the one hand and the new interest in wildlife on the other, has resulted in a definite effort by entomologists and wildlife conservationists to work out a harmonious program.

A major factor which has influenced insect problems is the notable higher standard of living which prevails. Beautification of homes as expressed by trees, shrubs and flowers has resulted in extensive plantings. Modern landscaping calls for many exotic plants, and with them new pests have been introduced and disseminated. Furthermore, soil disturbances during building operations frequently create abnormal and unfavorable soil conditions for such plantings which reduces vigor of plant growth and increases susceptibility to insect pests.

Food standards might well be mentioned. I have already spoken of the insect conscious public which now demands worm-free apples resulting in the necessity of better control of the codling moth. Similarly, where once the housewife thought nothing of a beetle or two in the oatmeal, she now demands foods free from any visible insect or insect fragment, which perhaps is the major reason for the almost universal use of insect-proof packages for dried food products of all kinds. During recent years there has been a deluge of requirements under the heading of adulteration which includes visible insect fragments and excrement in canned and dried food products. Who knows but that the next logical step will be regulations prohibiting the sale of insect-infested fresh fruits and vegetables comparable with the present regulations dealing with processed products. And what about insect contamination of the increasingly popular frozen fruits and vegetables? All of these factors add responsibilities on the entomologist, for it becomes evident that more nearly perfect control must be our objective. While some regulations have stressed the need for more nearly perfect control, others have tended to discourage the use of some of our best insecticides through the use of which the degree of control demanded may be obtained. Needless to say I am referring to tolerance regulations on in-

secticide residues. It is not the intention to question or argue the justness of such regulations, but I do believe that much harm has resulted from undue publicity provided by federal and state officials, as well as that emphasized by manufacturers of so-called non-poisonous insecticides. So much emphasis has been given to the danger of insecticides that more and more we find federal, state, city and private specifications for insect and rodent control requiring the use of non-poisonous materials, when as a matter of fact the danger from the proper use of materials poisonous to humans is practically nil when in the hands of an experienced operator. For example, there is little basis for specifying the use of a non-poisonous material in a contract for controlling cockroaches in a building, when a fluorine compound will give better results and without danger if applied properly. My plea is that we give less stress in our publicity to non-poisonous preparations and instead emphasize the importance of correct use.

Living standards on this continent have changed and are continuing to change. Not many years ago we thought nothing of a bedbug or so in our hotel accommodations, and the leasee of an apartment gave little concern to cockroaches, silverfish or ants. Now we blacklist the hotel where we have encountered a bedbug, and the apartment renter is ready to cancel his lease if he observes a bug of any kind. The fact that hotels and apartments are now generally free from bedbugs and other vermin is the result of the demands of an insect-conscious public and the effective work of the pest control operator.

The present trend toward the centralization and regulation of agricultural activities by the federal government, including the control of crop acreage, crop surpluses, prices, etc., are certain to change insect problems and develop new ones which may tax the ingenuity of the entomologist to a greater extent than ever before. In reply to an inquiry referring to the above problems, addressed to the Secretary of Agriculture, I received under date of October 5, 1938, a very enlightening letter from the Honorable M. R. Wilson, Acting Secretary. The comments are so appropriate I am quoting the major paragraphs, as follows:

"In the early years of modern development of the science, what the farmers and the general public wanted from it was knowledge and direction that would both cut the cost of producing a pound or a bushel or a bale of farm products and at the same time increase the volume of production in any one year. There was then a market here or abroad, by and large, for all that the American farmers could turn out. It was wasteful of human labor to bring farm products part way to maturity and then see them serve the insect appetite instead of the needs of humanity.

"It is still wasteful to have such a thing occur. And the farm operators and the general public still wish economic entomology practiced so as to conserve labor and land resources and not waste them on growing food for insects. This is true in spite of the fact that the agricultural economic position has changed; that no longer is there a sufficiently increasing market for a constantly increasing output of farm products. This very change in the agricultural economic situation makes it more important than ever to keep down the costs of production through control of insect pests and by all other possible means.

"It is true that the present day trend is to avoid excessive output—but the preferred method obviously is to do this by adjusting acreage, not by surrendering crops in the field or stored products in the bin to insect pests.

"As a matter of fact, pest control is important in connection with crop adjustment. The only kind of production that can be efficiently regulated is efficient production. With acreage adjusted more nearly to the expected demand, the need for fairly stable yields increases. This puts an increasing premium on control of pests attacking the crops whose producers seek protection for price and income through the method of acreage adjustment.

"Likewise, the producers of the numerous crops which do not come within the acreage adjustment program find a growing need for efficient pest control. Competition in these crops is keen; marketing agreements and surplus-removal programs do not make things easy even for the most efficient producers. They must apply all means they can find of cutting down their costs of producing each bushel or pound of their crops.

"In brief, pest control becomes more rather than less important in the present economic situation in agriculture.

"Cooperative pest control is here already. Eventually, it may have some tie-up with the crop insurance program, which seeks to give insured farmers an incentive to take good care of their crops. Differential rates in crop insurance will encourage farmers in pest control through both individual and concerted action. It is plain, too, that the control of insects that attack stored products has increasing importance. The ever normal granary program, which provides for increased storage on the farm as well as in country and terminal elevators, directs attention to this problem.

"In farming it is necessary to harmonize technical progress with economic adjustment. Every branch of agricultural science, with entomology in the front rank, has some responsibility. There is no conflict between the technology and the economics of agriculture. Even when the market shrinks, there is no excuse for relaxing the control of pests and diseases. Many people think it strange that the technical branches of this Department should study how production per acre may be increased while the Agricultural Adjustment Administration emphasizes the importance of regulating supplies to the reduced demand. Actually, the readjustment of agriculture makes as heavy a draft on the technical as it does on the economic branches; it calls for the combined application of entomology, soil science, genetics, nutrition knowledge and economics in an extremely complex readjustment of the whole agricultural economy."

These comments from one who is interested in agriculture in its broadest sense and who is familiar with the present policies of the federal government, emphasize the importance of insect problems and signify above all the necessity of continued and enlarged research to meet the problems almost certain to develop with the changing agricultural situation.

May we comment on and reiterate further the many new ideas and interests being exploited, as a direct and indirect result of the changed economic situations of recent years, which have been too often promoted without consideration of the insect problems involved. Reforestation, erosion control, the marginal land problem, water impoundment projects, wildlife conservation and control of surplus crops are among the problems referred to in which no consideration or insufficient consideration to insects has been given. For example, the storage of grain, in the ever normal granary plan, with concomitant control of pests, is one wherein the insects may play a major part. To be sure, perhaps more attention has been given to the insect problem involved in this than in any of the other newer projects, and yet in spite of the desirable features of the plan it is extremely doubtful if sufficient study has been given to facilities now available on the farm to insure safeguards against grain-infesting insects, or to the costs to the farmer of providing needed facilities.

GOVERNMENT ACTIVITY IN INSECT CONTROL.—Some 75 years ago the decision was made that the federal government should make the promotion of agriculture a part of its concern. Economic entomology became a significant factor in the agricultural program and has grown phenomenally, largely because of the growth of federal assistance to agriculture. Until 1914 entomological work of both federal and state agencies was largely along the lines of research and investigations essential to the development of insect prevention and control. Extension Service as a definite project was made national in scope under the Smith-Lever Bill in 1914, and although the establishment of this service may be attributed to the success of cotton boll weevil demonstration activities, beginning ten years before, extension work in entomology did not develop as such to any great extent until within recent years. Without a doubt the inauguration of extension work, as a definite field of activity in entomology may be considered one of the notable milestones in its applied aspects of the science.

Entomology has gone further. It has got into the big money with its so-called extermination campaigns. The campaign conducted against the Mediterranan fruit fly was apparently successful and well worth while. On the other hand the $10,000,000 corn borer extermination program resulted in a boomerang to the science of entomology. And yet this should not be attributed to an error on

the part of the entomologists for this project was inaugurated and insisted upon by others than entomologists; in fact, it might be said that at the very outset the project was questioned and certainly not generally supported by entomologists.

A more recent development is appropriations amounting to millions of dollars to assist farmers in the control of such insects as the chinch bug and the grasshopper. We grant there are areas where federal aid was needed, but the lavish use of funds has resulted in some cases in affecting farmer initiative, one of the most valuable traits of man, and an expectation of aid for every problem that develops even to the extend of expecting aid in applying material furnished by the government. Undoubtedly the public is looking more and more to the government for insect control aid. We do not infer that federal or state aid is unwise in some instances, but we do believe that often such aid may be administered too freely and as a result delay progress in practical insect control. It is our belief that initiative on the part of the producer is essential in practical and efficient insect prevention and control and without it an increasing burden is placed on the official entomologist. The conditions I have just briefly related are bound to reflect on entomology as a whole and on the future necessary changes in entomological procedure.

Another activity as it affects entomology and related sciences is that organized under the Works Progress Administration. So long as WPA activities provide work to the unemployed, are administered for the benefit of the legitimately unemployed, concern a reasonably desirable project and do not interfere with legitimate business, we can find no fault. Thus the mosquito control projects, largely labor projects, can be supported under existing conditions. But let us step outside the field of entomology to illustrate our point of the undesirable features which may develop. We are thinking particularly of WPA rat control projects which have been sponsored in some cities. To spend hundreds of thousands of dollars distributing rat poisons and at the same time permit exposed garbage to accumulate in quantity, as I myself have seen in Chicago alleys, and even in the "Loop" district of that city, is a waste of money and interference with the legitimate business of the pest control operator. Had WPA money been properly used to clean up rat harbors, there could have been no objection, and much good would have been accomplished.

POLITICAL ACTIVITY AND ITS EFFECT ON FUTURE INSECT CONTROL.—In referring to political activities may I at once assure you that I do not refer to present American politics. Nevertheless, the trend in some countries is such as to warrant consideration of the problem here. Some have expressed a feeling that such recent developments as the ever normal granary plan may lead to requirements which may become political issues. However, at this time, in speaking of political activities, I have in mind such drastic policies as are being inaugurated and carried out in countries such as Germany, where we may expect a demand for the adoption of definite practices for insect control, and, what I personally fear most, the effect of such mandates on research and, as a result, a science so directed that results are predetermined. In making this statement I have before me the picture so wonderfully described by Eva Lipps in her book *Savage Symphony*. It is to be hoped that those who direct the policies of the United States and Canada may ever keep in mind the fact that any progressive science demands a free field for its activities and that we may never come to the point of demanding predetermined results or restricting unbiased scientific activity in any way, thus jeopardizing the future of world democracy.

TRENDS IN THE MAJOR FIELDS OF ENTOMOLOGY.—Unbelievable advances have been made in the various fields of entomology during the past 3 score and 10 years. New and unlimited fields of activity have been uncovered which may be attributed largely to changes in living standards and the attitude of the public. More and more the public is realizing that insects are a dominating factor in the destinies of life and is recognizing the need of commercial agencies for insect control. Thus, we find new fields opening up for those entomologically trained and opportunities for all interested in the subject, whether their interests be toward teaching, research, extension, regulation or business. But at the start we wish to insist that the prime requisite of an entomolo-

gist, regardless of the phase of work contemplated, is a real and sincere interest in the subject. We mention this specifically because there is an inclination on the part of many college students to major in entomology because of the possibilities of a job. In other words, there is an unfortunate tendency for persons to enter the field of entomology solely for financial reasons rather than because of their real interest in the subject. We do not wish to underestimate the importance of financial returns but we do feel that an interest in the subject itself should be a determining factor.

The field of teaching is perhaps the most vital within the scope of entomology, because achievements in the subject, to a large degree, are dependent on the development of men properly and adequately trained. As I view the situation, entomological instruction has become almost a "dead language," figuratively speaking. Teachers have recognized the need of providing service courses for branches of agriculture which have considered entomology an important phase of training for their students. The teachers of entomology have served well in this respect. They have recognized the need of developing men for research work and here again they have performed a notable service. But here they have stopped. They have not realized that, in spite of the additional opportunities in research laboratories of commercial concerns, there is slight or no increase in funds for research personnel in the federal or state agencies. Large funds are being made available for insect control operations, to be sure, but very little if any of this is available for fundamental or practical research. In other words, the field of research in entomology seems to have reached the point of saturation.

It is the duty of the teacher of entomology in schools where an entomological curriculum is provided to prepare students for an available as well as a profitable vocation. With possible exceptions, this they are not doing because they are preparing students primarily for technical research and have given little consideration to other opportunities, especially those which we may refer to as commercial. They have not explored the situation, or let us say the changing conditions, and not having realized the necessity of finding new fields of work for the students of entomology, they have not trained these students accordingly. Some of these new fields are being forced upon us. We can anticipate a future for those interested in extension entomology. Regulatory work will call for an increasing number of trained men. Insecticide manufacturers are calling for more men, not only for their research laboratories but for sales promotion work. There is an unlimited field for the commercial entomologist, and by this term I am thinking of consulting entomologists and pest control operators or pest exterminators. And yet there is perhaps no educational institution in the United States or Canada giving appreciable consideration to the development of men for such careers. Again I say that it is the duty of the teacher to consider these new fields and provide training to meet the new conditions if he is to continue to encourage qualified students to follow entomology as a vocation.

There is another obligation which the teacher should never forget. I refer to endorsements he may give his students. Because a student has received good grades and, let us say, shown promise in research, is no sign he will succeed as an extension worker or in the commercial field. Let us think of the pest control operator, or exterminator, as he has been commonly referred to in the past. The better pest control operators recognize the need of more training in technical entomology than most of them have received and some have employed men who have completed a major in the subject. Unfortunately not a few of the men employed have proved unequipped for such work, in spite of high endorsements. Consequently their employers have come to the conclusion that entomologically trained men are not qualified for the practical work of pest control. This is very unfortunate because we believe the commercial field of pest control is an important industry in which more well-trained entomologists should participate. In other words, we wish to leave with the teacher the thought that there is a variety of fields in entomology, suited for an equal variety of human personalities, and that recommendation be made on the basis of qualifications for the type of work as well as qualifications in entomology.

Taxonomy, the very foundation of applied entomology, has made continuous advancement from early times. The early taxonomists were, with few exceptions, men and women interested in insects, for entomology was not their vocation. They were what we might call collectors or hobbyists. Today there are too few Says, LeContes, Harrises, Williamsons, Caseys, Pergandes, Schwartzes, Edwards, Cressons and others of their kind who devote their lives to insect study, not because of financial returns but because of their intense interest in the subject. To be sure, the museums of the nation are more and more developing the taxonomic side and are employing an increasing number of men and women qualified in this important field. Moreover, many men employed in teaching and research are doing excellent taxonomic work, but there is a decreasing number of taxonomists who are following this phase of entomology as an avocation.

There is a silver lining in this changing world, however, for the extension entomologists are building up rapidly a popular interest in entomology through the organization of 4-H insect clubs and as a result we may anticipate a revived interest in entomology as an avocation. We feel that this new interest, or may we say changed interest, is a hopeful sign. It is to be hoped that there will soon develop some Blatchleys who will provide for the use of these new recruits popular books on all the orders of insects along the understandable lines of the famous Blatchley book on Coleoptera.

In research we also see very definite trends. At present there seems little tendency to increase research either in federal or state set-ups in spite of the increased funds available for insect control work. Commercial organizations, however, are very definitely recognizing the importance of research with respect to the future development of business. With the many problems which must be solved, it is inconceivable that research activities will not be enlarged, even though perhaps not to the extent of the increasing number of men preparing themselves for this type of work. We must recognize that research is becoming more technical, and there is a greater intergrading of the sciences, necessitating more thorough and general preparation, which of course necessitates additional graduate studies. Teachers must recognize the necessity of more thoroughness, not only in entomology but in other closely related sciences.

Extension entomology has been slow in starting, as has already been indicated. But every entomologist realizes that the application of the results of research can be secured best by the extension specialist who has the qualifications necessary to "sell" the public. Thus we find, with the wonderful results being obtained by such specialists, that extension work in entomology is gaining endorsement and we may look forward to an activity of greatest importance in the future and, with this, greater use of the results of entomological research.

The field of quarantine or regulatory work as it applies to insects is one which has made notable progress during the past 40 years but the future will witness changes and additions in keeping with changing conditions. Past experience indicates that many state and federal laws have been too hastily drawn up to meet a special need, and in some cases laws are so broadly or loosely stated as to give unreasonable powers to a governing body.

The advent of the San José scale was responsible for many state laws requiring the inspection and certification of nursery stock. These early measures were drawn up by each state with little consideration given to regulatory measures in other states. Recognizing the need of greater uniformity the American Association of Nurserymen and the American Association of Economic Entomologists, working together, worked out a "model" nursery inspection law, which has been the guide to practically all, if not all, present day state laws. As a result, nursery inspection has become an established and satisfactory fixture among the regulations dealing with insect control. Federal regulations, enacted to prevent the introduction of insects foreign to America, and to prevent or minimize spread of insects from one area to another, have been developed to a point where they too are providing a real service. Apiary inspection, to control bee diseases, is a service provided in most states, but rarely are funds available to protect the good beekeeper adequately. Therefore bee diseases are still important limiting factors in honey production.

Nearly 30 years ago, Congress enacted a law intended to regulate the sale of insecticides for the protection of the people. Several states have similar laws regulating insecticides for intrastate sale. Although these laws have rather effectively governed the marketing of some insecticides, such as the arsenicals, they have very definitely fallen short in protecting the public against many types of insecticides. There is activity at the present time to remedy these shortcomings, probably largely due to the great increase in the number of insecticides being placed on the market and the extravagant claims being made by some manufacturers. Regulations, most of which are federal, governing insecticide residues on edible food products and insect or insect-excrement contaminated food are moot questions. Suffice to say that the whole problem is one which needs far more study than has been given. Where insecticide or insect contamination is a detriment to health, such regulations are warranted but we would go back to our earlier premise, that laws of this kind should not be enacted hastily nor until they can be based on substantiated facts.

There is one additional type of legislative regulation which seems very essential in the near future to safeguard lives and more especially to prevent the functioning of impostor pest control operators, especially termite control operators, who are tricking the public and definitely harming the legitimate pest control industry. This is an industry which should be controlled by states and so far as we know only three states, California, Louisiana and Mississippi, have laws governing pest control operators, by which we refer to those who practice the commercial control of insects in hotels, apartments and other buildings. Many states have indicated the intention of enacting legislation necessitated by changing conditions. Our Association has a committee, working in cooperation with the National Pest Control Association, and it is to be hoped a model law, recognizing the essential fundamentals, will soon be available and that states will avoid hasty enactment of legislation.

CONCLUSION.—In the foregoing remarks I have stressed changing conditions which may increase the significance of insects and yet we should also realize that instead of increasing the importance of insects some changes may materially decrease their importance. For example, the reduction in the importance of the alfalfa weevil in certain areas may be attributed to the shift from range to dairy cattle. Such livestock require less hay, which results in earlier cutting of the first crop, thus preventing the completion of the first brood and in material reduction in weevil infestation.

I have brought to your attention problems and trends with which doubtless already you are aware. It has been my intention to emphasize them that we may keep them ever before us in our planning for the future to the end that we may not lose sight of the fact that entomology is a science of great importance in many, if not all, of the problems resulting from this changing world, and that it should be recognized as a factor which must not be ignored.

I have been critical in my consideration of these problems, not to condemn procedures which are familiar to all of us but to arouse interest in the necessity of having entomologists realize their responsibility and to point out problems for which the future entomologist will be answerable.

A VIRUS disease of peach trees known as the "X" disease is the subject of a quarantine placed by the state of New Jersey, January 17, on the entry of peach and chokecherry nursery stock from the states of Massachusetts, Connecticut, Rhode Island and New York.

RECENT modifications of the oriental fruit moth quarantines of California, Oregon and Washington provide that the host plants (not including haw or hawthorn), if bare-rooted and fumigated according to specifications, may enter the state during the dormant period—from November 1 to April 1 in the case of the states of California and Washington and from November 1 to March 15 in the case of Oregon.

THE United States Department of Agriculture placed a quarantine, effective January 15, 1939, on account of white-fringed beetle infestations in Florida, Alabama, Mississippi and Louisiana. Modifications of the regulations as well as treatment prescribed for plants and soil are covered by supplemental administrative instructions of the Bureau of Entomology and Plant Quarantine, circulars B.E.P.Q. 485, 486, 488 and 489.

Agencies Utilized in Disseminating Information on Insect Control*

Commercial Agencies for Disseminating Information on Insect Control

T. H. Parks, *Ohio State University, Columbus*

The importance of controlling insects, even in times of burdensome crop surpluses, is looked upon as essential by producer and consumer alike. The increasing demand for dependable information on how to prevent or control injurious insects is shown by the rapid growth in personnel and services of the Bureau of Entomology and Plant Quarantine of the U. S. Department of Agriculture and the various state experiment stations during the past 25 years. During this time the extension entomologist came into being. Still more recently, various commercial and industrial organizations have recognized entomology in their business to the extent of contributing in a substantial way to research studies on inscet control or of employing an entomologist whom, for want of a better name, we call the "commercial entomologist."

All entomologists who have to do with insect control work are making a definite contribution in the field of extension. Entomologists engaged in research, teaching, regulatory work or commercial activities are closely allied with extension problems. It belongs to the extension entomologist, however, to evaluate the most urgent needs within his state and to formulate a yearly program of organized insect control. By control we mean preventing outbreaks as well as reducing the existing insect populations.

The extension entomologist is, first of all, a teacher. He must see that his instruction reaches the public, whether in written or spoken form, whether from him direct or amplified by others. His teachings must stimulate voluntary action, for no law enforcement is behind his work. His results must be measured in changed practices that are brought about voluntarily, whether these practices are in the fields of health and sanitation, agriculture or industry. And what a job he makes for himself when he offers his aid in the solution of miscellaneous problems! If you doubt this, just announce over your local radio station that your office stands ready to help solve any problem having to do with insects of the garden, home, flowers and shade trees. Brave indeed is such an entomologist, for he will soon be deluged with questions about termites, ants, sick trees, blights, wireworms, corn earworms, borers in flowers, or even how to get bad odors out of a house. Then he realizes that he probably has been too big-hearted and has taken in too much territory in his moment of generosity. The public is indeed interested in our work and ready to receive it when sound and practical. How then can we best serve those who need our help?

If we have not thought it necessary up to this point, we must now realize that extension teaching and insect control must be done *through*, but not necessarily entirely *by*, the entomologist. The extension entomologist must realize this fact, or the spread of his services will be greatly restricted. If he wishes to encourage the use of a new and improved insecticide in place of an old familiar one no longer desirable, he will reach the goal sooner by enlisting the help of the various agencies contacting the growers and educate them to extend his teachings.

Insecticide, fertilizer and spray machinery manufacturers, as well as officials of floral supply houses, farm bureau service companies, wholesale and retail seed and insecticide companies, local banks, local canning companies, grain elevators, commercial spray companies, exterminating companies and railroads have all shown their ability to amplify our recommendations and aid in insect control work. These agencies are separate and apart from the farm and home organizations of a social, health or educational nature. They may have mercenary motives, but they reach many people who would not be reached by an extension organization.

Insecticide salesmen, trained by commercial and extension entomologists, cooperating with each other, can aid greatly in disseminating our information to dealers and fruit growers. In Ohio we have a

* A symposium before the Section of Extension, American Association of Economic Entomologists, Indianapolis, Ind., December 28, 1937.

gentleman's agreement with a large oil company that its specialty sales force will conform completely to the recommendations put out by the experiment station and university. These district salesmen are usually found in our audience at fruit meetings. They have a special conference annually with entomologists and horticulturists of the experiment station and university. At this meeting our recommendations are explained and in our presence their products are fitted into the program by their general supervisor, who is noted for his wisdom and good judgment. The advertising literature of this company carries directions for the mixing and use of dormant oils that are approved each year by the state entomologists.

Two of the largest seed companies in Ohio have purchased 10,000 copies each of our garden insect and disease bulletin, and are distributing them from their stores. The catalog of another seed company and that of a leading spray machinery manufacturing company carry recommendations prepared by the extension entomologist.

Probably the greatest opportunity for amplifying the recommendations of the college and experiment station is through the smaller retail dealers in insecticides. We have enlisted their aid in instructing the public, and each year hold one-day insecticide dealers' schools located in counties throughout the state. These consist usually of afternoon or evening meeting and are held for the purpose of instructing dealers in the proper control recommendations. As a result of these meetings we reach many people over the counter of the retail store, where the dealer amplifies our recommendations. The extension entomologist follows up these meetings, as far as possible, with a visit to the retail store, where an inventory is taken of the stock on hand and where he leaves a reference bulletin for the sales force to consult when necessary.

Canning factories are also in a position to help along this line. The production manager of a large canning factory in Ottawa County, Ohio, felt that the farmers growing pickles for the factory were not getting satisfactory yields, because of insects and diseases. He investigated and found that they were in most cases dusting hydrated lime on the plants to repel cucumber beetles. The manager then called a meeting of the growers, at which the extension entomologist was invited to outline control measures for these insects. Following this meeting, the factory signed contracts only with those growers who agreed to use the recommended mixture of calcium arsenate and gypsum dust as their insecticide. The factory furnished this mixture at cost to all of the growers contracting to grow pickles and subtracted the amount from the crop returns at the end of the season. The result was an immediate increase in acre yield of pickles due to better control of the striped cucumber beetles and healthier condition of the plants. During the next year over 50 tons of the calcium arsenate and gypsum mixture were sold to growers by this factory. Three pickle factories are now using the method outlined here.

We have used Rotary and Kiwanis clubs to arouse interest in mosquito control for municipalities and to discuss termites and their control in city buildings. Moving pictures are well adapted to meetings of such clubs. One county-seat town secured a state health department sanitary engineer, who mapped out a system of drainage that put an end to the city's mosquito nuisance.

Fly-free dates and armyworm poisoning information have been disseminated in part by officials of grain elevators, railroads, banks and local farm bureaus. We should enlist the aid of these commercial agencies in our major control campaigns. Commercial spray operators and commercial exterminating companies frequently call upon us for advice in identification of specimens and methods of control. We have found these highly specialized industries very cooperative. One of the leading arboretists in Cleveland is promoting regular meetings of city and suburban estate managers where we are periodically called in to advise about insect control.

We have utilized the better business bureaus in policing unscrupulous exterminating operators who misrepresent the facts and break down the confidence of the public.

While our university owned radio station serves as a medium for extending practical information, we have found commercial radio stations valuable aids in entomological extension work. Our fruit

spray service recommendations are put out three times each week from Cleveland, Cincinnati and Toledo commercial stations. These stations enable us to talk to each fruit grower in our state throughout the spray season. Perhaps, this is the greatest single service performed by our commercial agencies and is highly valued by the growers. Ten other commercial radio stations in Ohio, West Virginia and Indiana serve our county agents during the growing season. These agents have scheduled times to use the radio and eagerly use our material.

All of these agencies serve as amplifiers of our recommendations. Are we fully aware of their power to serve, and are we using them to the best advantage?—12-22-38.

Visual Instruction as an Agency for Extending Entomological Information

R. R. REPPERT, *Texas Extension Service, College Station*

Entomologists in the field of extension work must on frequent occasions have decried the lack of interest and the difficulty experienced in arousing the public to an appreciation of the importance of entomology. When faced with an emergency in the form of extreme damage by some particular insect, farmers and others clamor for aid and are enthusiastic in their support of a campaign of control; but with the passing of the emergency their interest wanes and they lapse again into an attitude of indifference to the entomological program. The fact that the normal crop loss due to insects is more than 10 per cent and annually amounts to several billion dollars appears generally to be unimpressive.

In presenting this subject, "Visual Instruction as an Agency for Extending Entomological Information," we do not presume to believe that we are pioneers in the field. Workers in various fields of endeavor have long appreciated that the average mind is more quickly and easily impressed by that which is presented to the eye in a novel and striking way than by that which is presented to the consciousness through the spoken word. Notwithstanding the disdain in which the comic sheet is often held, it is significant that the newspapers, sensitive as they are to the public demand, are continuously increasing the space devoted to this method of presenting both entertainment and instruction. Note also the increasing number of papers using simply pages of photographs portraying news. Manufacturers alert to meet competition are spending immense sums to get the attention of the public through novel visual means. Various social and charitable associations, federal activities and other organizations that must depend for their success on the extent to which they appeal to the public sympathy have been quick to appreciate the value of the visual approach and by innumerable devices have striven to arrest attention.

It is surprising how interested people will become and how well a lesson may be impressed by the use of the blackboard. A formula written out means a great deal more than one spoken. Drawings, if used, need not be elaborate—in fact, the purpose may be defeated by too much detail. One may use lines—lines so simple or perhaps so crude that alone they would mean nothing; yet with a few words spoken to stimulate the imagination of the audience, one can present a very real and effective picture. For instance, we might draw one horizontal line and say: "This is the ground line." Then three or four lines radiating upward from a point on this horizontal line are explained as representing a bunch of grass; add some curved lines extending into the soil under this grass with small ellipses drawn within, and possibly a crude drawing of an insect in connection, supported by suggestions, and in less than 10 seconds one has given his audience just about as vivid an understanding of how and where grasshopper eggs are laid as if a photograph were presented; a picture even more impelling because members of the audience have seen it develop before their eyes. This method can be used with adults, as well as before club members, in a school room or elsewhere.

The same idea can be applied to the preparation of mimeographed leaflets. Some entertaining feature can be mimeographed, though of course, this must carry a point and should not be overdone. We will, of course, as entomologists, appreciate the value of a technically correct drawing of an insect on printed circulars,

and, so far as can be provided, on mimeographed sheets as well as on posters.

If you have used film strips, you already fully appreciate their value. If you have not used them, try one on a subject you are presenting as of immediate interest. We have found them invaluable and have wondered why specialists in other subjects of our organization have not made greater use of them. Extension service organizations of some states are using moving pictures with success. A commercial company in Texas showed the cotton flea hopper movie film in meetings, called for this purpose only, to a total of over 16,000 interested people during 1937.

Photographs have their place, but only good ones, clearly setting forth the point desired, should be shown. They should be placed on a wall or board for examination at the leisure of the group, and should never be passed during the lecture, since, under these circumstances, they cannot be properly explained to a group; and then the confusion of passing them from one person to another detracts interest from what is being said.

There should be no question in the mind of any one as to the value of exhibits. They have long been used at community, county and state fairs to acquaint the public with activities of agricultural workers in lines of work other than entomology; but we doubt if entomologists generally have utilized this means of visual education as much as they should. We have been negligent in this respect, though the results apparent from the limited effort we have expended in preparing such exhibits has convinced us that we might well extend this activity. An exhibit should include some feature designed primarily to attract the attention of people as they pass by; if it can be made amusing, the better. This part will not necessarily appeal to the technical mind; one should not depart from actualities unnecessarily. Motion always attracts and, if the exhibit can be mechanized, its drawing power will be increased.

A year ago, in exhibits to acquaint the cotton growers of our state with what had been accomplished in flea hopper control, we made our attractive feature a miniature field of cotton with cotton pickers, carts, mules, etc., and with a painted background carrying out the general effect of a southern plantation. One farmer visitor had to threaten to "whip" his small boy before he could move on to other exhibits. In many other cases observed by us, farmers paused to look at the photographs, read the placards, and so get the real lesson which many would not have done, had they not been compelled to wait while their children looked over what was to them the more interesting part. The more serious and instructive part of the exhibit will include photographs, which should be clear and to the point; placards, short, easily read and not excessive as to number; specimens of plants or parts of plants, if available, showing characteristic damage and, if possible, a prepared specimen of the insect shown in the act of inflicting damage; tables giving data in the briefest manner possible; miniatures of the machinery or equipment used in control; and some means of representing graphically the production on treated and untreated plots. Cages of the live insects will add greatly to the exhibit, if these are available.

Exhibits of the above nature, reduced as to size or number of features as circumstances may require, can be set up in banks, county agents' offices or other public places. In such places they will be found effective in arousing interest in control campaigns. We have seen general interest aroused and a control campaign started by a jar containing grasshopper eggs placed in a bank where patrons on successive visits could view them and in time observe their final development into tiny hoppers, jumping about inside the glass. One of the most effective exhibits of this sort which we have ever seen was provided by the U. S. Bureau of Biological Survey workers. This consisted of a cage in the form of a very shallow wooden box, faced on one side with glass and filled with dirt; in the cage was a gopher which, because of its narrow quarters, was always visible through the glass as it worked the dirt back and forth in its efforts at excavation.

Some types of insects lend themselves admirably to such a prepared exhibit. In our state we have a certain fungous ant known as the leaf cutting ant that builds nests, in some instances over 100 feet across. These ants destroy considerable areas of cultivated crops, using the foli-

age as a medium upon which to cultivate their food fungus in underground cavities. At our direction, county agents and club boys have exhibited artificial colonies of these ants in a glass cage somewhat similar to that mentioned previously for a gopher exhibit. In these artificial colonies the ants make their runways and excavations, and rebuild their fungous gardens, many of them next to the glass, and so they can be readily seen and studied by the spectators. These exhibits have never failed to attract attention and to elicit numerous inquiries as to the insects' habits and the methods of controlling them.

We realize this subject has not been fully covered but enough has been said to show that visual means of presenting entomology may take many forms. One undertaking such means for the first time is sure to be pleased with the results and will be encouraged to develop further ideas of his own.—12-22-38.

Visual Aids and Their Value in Entomological Extension Work

G. E. LEHKER, *Purdue University, Lafayette, Ind.*

More than 40 years ago the late Dr. Stephen A. Forbes wrote in part as follows: "It is not the facts of entomology we discover, but those which we persuade the farmer, the gardener or the fruit grower to use diligently for the protection or the preservation of his crops, which make our entomology economic. To bring a result to bear on the practice of one man when a thousand are suffering from the want of it is to fail 99.9 per cent of our proper undertaking. We must first do exhaustive, conclusive, practical economic work, and then we must find means to get that work utilized or it is an economic dead loss."

During the 40 odd years that have passed since Dr. Forbes made these statements, most of us in this room have been appointed to fill the gap to which he made reference. I am wondering tonight just how many of us are doing the job to the best of our abilities. Can we merely talk to a group of our listeners and persuade them to adopt insect control practices? No, not all of them, simply because it is not human nature—it is not possible—for man to grasp, comprehend and put into practice all of those ideas that reach his mind by means of the spoken word. I believe, therefore, that we owe it to ourselves and to our constituents to do all that we possibly can to present our information in a way that the human mind is fully capable of understanding. Because of the fundamental fact that the eye is quicker than the ear, I believe that to accomplish this, the use of visual instruction is second only to actual method demonstrations.—12-22-38.

NOTE.—*Mr. Lehker demonstrated the use of some visual aids used to further his own projects and explained their application to everyday extension problems. Among these were the following:*

1. Chalk drawings to show the life history and habits of termites.

2. Large model termites to show the organization of a termite colony.

3. Model beetles with and without money sacks to illustrate that many inconspicuous insects cause huge losses.

4. Dusters containing talcum powder to illustrate the value of proper equipment for applying insecticides.

5. Small balloons and a hand atomizer to show the need for frequent codling moth sprays. The balloons were blown up to the size of a walnut and sprayed. They were then blown up to several times their original size, which clearly showed large areas of rubber not covered with spray material. It was then explained that apples likewise grow out of their spray coverings. In this same connection a life cycle of the codling moth was drawn on an easel board and the necessity pointed out for keeping the fruits protected at all times.

Demonstrations for Disseminating Entomological Information

W. C. NETTLES, *Clemson College, Clemson, S. C.*

Demonstrations constitute an important means of extending entomological information. Quite fitting is the place given to a discussion of demonstrations in this symposium; namely, at the bottom of the list, for demonstrations are the educational bed rock from which information is disseminated for most effective results.

Early in this century, Dr. Seaman A. Knapp started an educational system new to the world. Especially noteworthy to a

group of entomologists interested in improving their technique in disseminating information is the fact that an insect, the boll weevil, was responsible for the emphasis placed on this important tool, the demonstration. One does not have to search far for proof of the wisdom of Dr. Knapp's decision. The demonstrational method has come into its own in every state in the Union in disseminating agricultural and entomological information. In many of the states, a person known as an extension entomologist is employed to give demonstrations and utilize other methods of greatest possible effectiveness in extending entomological information.

Many people think that an extension entomologist should serve a state in much the same manner that a medical practioner serves a community. They expect him to be ready to answer all calls during insect outbreaks and also to visit personally, diagnose, prescribe and sympathize when a prized possession is damaged or destroyed by insects. While such an existence might really be most pleasant, it by no means constitutes all nor even the most important duty of an extension entomologist. As succeeding paragraphs point out, demonstrations must be regarded as an important part of his work.

The purpose of a demonstration is to point out or to make clear. In the past, insect demonstrations have had as their aim pointing out or making clear that a given insect may be controlled by a certain method or material, or to point out or make clear the identification of a certain pest or biological principle. Demonstrations may be subdivided into those relating to method and those relating to results. Chicken louse control is an excellent subject for a method demonstration. In this demonstration poultry raisers can be shown every detail necessary to accomplishment of the job. In such a method demonstration there is wide range of choice in the person who demonstrates. The demonstrator may be the extension entomologist, a county agent or one of a demonstration team. A 4-H Club team demonstration of louse control on poultry was a distinct success at the South Carolina State Fair. The demonstrators were two carefully chosen club boys of high school age. They put on this demonstration to hundreds of individuals in numerous appearances in their home county and many times at the State Fair. Extension specialists gave all possible assistance and assembled subject matter information for them. These boys impressed hundreds of people. Team demonstrations in the South have been somewhat neglected, but, with training, 4-H Club team demonstrations will become an important agency in the dissemination of entomological information. Result demonstrations have been said to be:

> "Mirrors of the past
> Guides for the present and
> Charts for the future."

Unless results of insect control demonstrations are recorded and an effort carefully made to place a value on them, the mirrors will be blurred, the guides irresponsible and charts inaccurate. In South Carolina, the director of extenstion expects extension specialists to pay particular attention to result demonstrations. The first duty of the South Carolina extension entomologist, then, is to plan, execute and report result demonstrations. Many extension workers do not consider a demonstration completed until results are recorded, analyzed and reported back to the cooperating farmer and to the public.

Long ago Dr. Knapp stated, in effect, that results should be written on the soil. By that he meant that demonstrations should be located with farmers and the value of a practice made to show up clearly with the growing crop or animal. Results should first be written on the soil before campaigns for extending specific entomological information are undertaken by means of the press, bulletins, circulars, radio and visual means. The speaker should not minimize the importance of any of these agencies for extending entomological information, but in a way should consider all of them as agencies for completing demonstrations.

Leading educators say that about four-fifths of all learning comes by way of the eyes. This is additional proof that result demonstrations which show a lesson are valuable.

On the other hand it must be admitted that result demonstrations are costly and therefore only a few persons may be reached by each one. To overcome this difficulty, particular attention should be paid and preference given in selecting

as demonstrators persons of influence in their communities. Moreover, more emphasis might be given by county agents to meetings at result demonstrations.

The ideal arrangement for extending, for example, information for a new control for an insect is to arrange result demonstrations in many communities. Results should be assembled and reported the first year. Gradually demonstration results with the names of demonstrators, together with research results, should be publicized.

It seems that to extend entomological information most effectively, in the South at least, an extension entomologist should spend much time planning, executing and publicizing result demonstrations. In a surprisingly short time it will be found that many progressive persons will have made good practices their own.—12-22-38.

The Use of Radio in Entomological Extension Work

W. P. FLINT, *Illinois Natural History Survey and Illinois Agricultural Experiment Station, Urbana*

One of the most recent developments is making available information regarding research work is the radio. This medium is being developed more and more as a means of advertising or giving out information concerning commercial products and is rapidly taking a permanent place in extension work. It probably never will replace the detailed bulletin or popular circular, nor will it, at least to any great extent, replace the printed news articles. It can be used very effectively for the quick dissemination of information regarding new developments in the scientific field.

Perhaps the greatest place for the radio in extension work is in the dissemination of information on the timely application of research work. Radio lends itself particularly to the giving out of seasonal developments of insects and plant diseases and the proper time and manner in which to apply control measures. In this connection it may be used extensively.

Most of the large experiment stations now have available radio facilities which will reach over their respective states. If such facilities are not available, at the experiment station, many commercial radio stations will be found willing to cooperate in donating a few minutes a week to the broadcasting of extension information.

As an illustration of what may be accomplished in this way, we can use the broadcasting of information on orchard insects and diseases by the University of Illinois station and 25 other radio stations in Illinois, Indiana, Missouri, Iowa and Wisconsin during 1937. This service has been developed by the Kentucky, Indiana, and Illinois agricultural experiment stations; the Illinois Natural History Survey, Urbana; and the Deciduous Fruit Insect Laboratory at Vincennes, Indiana, of the U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.

Members of the staffs of the above mentioned agencies cooperated in developing weekly radio broadcasts designed to give the fruit growers of these states authentic information on the development of orchard insects and diseases; also to give the best information possible on the sprays to be applied and the reasons for so doing. Information on the development of insects and diseases is gathered at several points in Indiana, Kentucky and Illinois, from the field station experimental orchards and with the cooperation of a number of fruit growers. This information is assembled at a central point, summarized and given to the extension editor of the Illinois Agricultural Experiment Station, Urbana. Here it is slightly revised for radio and is then sent out to a number of radio stations which have previously agreed to broadcast this information at a given time each week.

We have found this method of employing the radio very helpful. The data are of more value due to the cooperation of the various agencies than it would be if it were all gathered by one state and did not include a great number of observations at various points in the different states.

In addition to a developed cooperative program such as the one mentioned, radio may be very effectively used for the dissemination of timely information on the control of insects and for the warning of farmers and others concerning impending insect outbreaks. Most of the state agricultural colleges and experiment stations

now have a regular agricultural radio program broadcast at a set time each day, or on several days of the week.

There are few items of more timely interest than those pertaining to insects, and radio offers to entomologists a means of quickly disseminating information—a means which they do not have through any other medium.—12-22-38.

The Press for Disseminating Entomological Information

C. B. DIBBLE, *Michigan State College, East Lansing*

The usefulness of the press in entomological extension work is determined by the answers to two questions: (a) Does the press create a consciousness of problems? (b) Does the press get action? It is safe to say that the press helps to bring about both but usually needs the backing of many other forces for widespread responses. Often people must be convinced that they have problems. This calls for one type of approach; the giving of directions to bring about the solution of their problems calls for an entirely different type.

The door of the press is always open for news. Unfortunately, tragedies have more news value than reminders of simple precautions to prevent them. If Brown's barn burns, that is news. If he takes out insurance against its burning, that does not get into the papers. It is the same with insect losses. It is more difficult to do a selling job of everyday precautionary measures against insect outbreaks than it is to disseminate information about meeting existing emergencies.

One great advantage offered by the press is that the printed word slips in the back door where other means are not invited or may not even be welcomed. The press constantly contacts potential customers with ideas, both new and old, that may result directly or indirectly in action responses. One never knows when great good can result from little effort expended. On the other hand, there is much competition for the reader's time and attention. Entomological information must compete with murders and politics on the front page, Moon Mullins on the last page and society news somewhere between. To meet this competition, the entomologist must use names, interest appeal and sometimes a touch of humor. He should strive always for accuracy and be sure that the information is timely.

Sometimes erroneous and worthless news articles receive wide publicity. This is illustrated by the widely circulated story about the use of castor beans to prevent grasshopper damage to crops and the use of Epsom salts as an insecticide for certain pests. The best way to combat this type of story is to furnish prepared articles for use in the local papers and gain the editor's confidence as to the sources of reliable information.

Perhaps we as entomologists are guilty of not using the press to the fullest extent of its ability and willingness to disseminate our information.—12-22-38.

Can We Adopt Uniform Methods for Measuring Results in Entomological Practices?

M. P. JONES, *U. S. Department of Agriculture, Extension Service*

When asked to discuss the above topic a few weeks ago, the author was prompted to write the extension entomologists for their opinions. The replies contained many helpful suggestions. The opinion most frequently expressed was that we cannot adopt uniform methods for measuring results in entomological practices, but in each case this statement was modified.

To answer this question it is necessary to go back farther than appears on the surface. The first factors to consider are found in answers to the following questions: For whom are we working? What are we to do for them? And what yardstick should we use to measure our results?

Are we attempting to eradicate the insect pest, effect 100 per cent control, or are we striving for sufficient control to permit adequate returns on the farmer's investment? In the commercial-production areas these results will necessarily be expressed in dollars and cents, whereas in non-commercial areas the returns will be the satisfaction that comes from an ample supply of fresh foods and the relief afforded from pestiferous and annoying insects.

In reading over the replies from vari-

ous workers, two phases of this problem became apparent: (1) The measuring of results of our whole teaching program; (2) the evaluation of each of the implements used to reach people, such as visual aids, radio and demonstrations.

In measuring the results of our whole project, the results of fruit-insect control can be measured more uniformly than other practices. We can always compare the fruit from trees sprayed according to our recommendations with the fruit of trees left unsprayed or sprayed without following our methods. By tabulating the entire fruit crop as to the proportion of high-grade fruit and comparing it with the price differential, it will be possible to evaluate our services to the growers who follow the spray service. This, however, may not tell the complete story, as much information has no doubt passed over the fence.

It is assumed that results can be measured each year. But can this be done? Do not the few ideas planted in any one year continue to spread for several years? If so, when should one measure his results to arrive at a reasonable answer? No doubt the project involved will have much to do with this fact. For instance, the work with juniors, whether direct or indirect, will continue to grow and, no matter what vocation the club member finally pursues, his knowledge of insect control will be useful.

In the case of insect outbreaks, some of which are more or less sporadic, control practices may last only a few years, but the check-up must be made within a reasonably short time. Such outbreaks are usually associated with climatic factors. As it is difficult to differentiate between insect injuries and other factors unfavorable to crop growth, measuring the results is further complicated. On the other hand, recurrent outbreaks of certain insects may be prevented, as in the case of the hessian fly. It is much easier now to stem the tide of an outbreak than it was in 1917, when observance of the safe-seeding date was first recommended.

The extent to which we should go in using outside agencies is a much-mooted question. Some think all entomological information should go direct to the farmer from the entomologist. Many believe that other subject-matter specialists or outside agencies can be used to reach more people. If we are obliged to measure our results by contacts with farmers, a specialist serving a large territory and working through all available agencies may not contact as many farmers as one serving a smaller, more thickly populated area. Under some conditions one may evaluate his results by the amount of insecticides sold in a given area. For instance, when the metallic compounds became taboo on vegetables, the specialist launched a campaign on the organic compounds. By writing the manufacturers, he was able to get the amount of the new insecticide moved into the area. The entire increased sale could not be credited to the entomologist, but most certainly his campaign accounted for much of it. This method might not be satisfactory in a general farming area. In the grasshopper campaign, the number of tons of bait scattered has been used as a measure of the effectiveness of extension work on this project. The sales of spray and dusting equipment have also been used to measure the number of people adopting better insect control practices.

County agent reports give much information, but such data should be checked very carefully before being used. As an example, the agent in one state having almost the lowest number of entomologists reported the highest number of entomological practices. Many of the control practices were antiquated and were not giving the greatest relief to the farmers. In other instances the agents had been doing much insect-control work under direct supervision of the entomologists, but failed to report.

With reference to evaluating the implements we use in stimulating farmers to adopt insect-control recommendations, surveys have been made rating several of them. Such a survey may not be correct, however, because the farmer is most likely to give credit to the last implement that came to his attention, whereas there may have been several things that helped to build up the interest gradually. The exhibit is considered by some people one of the poorest teaching tools, but most certainly it arouses sufficient interest to induce a farmer to read an article or attend a meeting where the subject of the exhibit is discussed.

The demonstration is perhaps the most convincing of our teaching methods, but,

unless many other tools are used to bring people to the demonstration, its value is much restricted. The demonstration does, however, lend itself to a wide variety of insect-control practices.

There are many factors that should govern the selection of the teaching implements we use. The policy of the state office and the talents of the individual worker should be considered. One person might accomplish much by giving a chalk talk; another might fail completely with the crayon. Some effort should be made to help the more backward groups, even though the task may appear hopeless at times. For such individuals, visual aids and the simplest forms of teaching should be used. Progress will naturally be slow, and the same measurement cannot be used for them as for a group of farmers combating an insect outbreak which is threatening their crops.

The relative merits of the radio have been questioned. Recent surveys have been made by commercial agencies to learn what programs appeal to rural people. In Pike County, Ill., the "National Farm and Home Hour" ranked second among the men, and seventeenth among the women. Among the men this program was outranked only by "Lum and Abner." In Burt County, Nebr., the "National Farm and Home Hour" ranked first among the men and sixth among the women. These surveys did not tell what portion of the rural people were listening to the "Farm and Home Hour" program, or how many farmers adjusted their farming practices to follow our suggestions. Certainly the radio cannot be relied upon to reach the more backward farmers.

Other ways of classifying the means of measuring results are (1) statistics, (2) symptoms and (3) attainment of goals. By means of the statistical method, for instance, one may, from packing-house records, compare the percentage of clean fruit from orchards where the owners followed our spray recommendations with that from orchards sprayed according to the farmers' own ideas; or by comparing sprayed and unsprayed trees, one can arrive at a pretty good dollar-value of our work.

Symptomatic measuring means considering conditions that are merely trends, for example, the increased volume of certain insecticides sold in a given area or the increased number of sprayers purchased by growers. Attendance at meetings is another symptom. The number of bulletins distributed in answer to requests may be an indicator, provided the farmer can find the answer to his question without reading through too many pages of superfluous matter.

Measuring results in terms of goals attained can best be illustrated by hessian fly control. Suppose, as our goal, we want 90 per cent of the farmers to observe fly-free dates. If, on a later survey, it is found that 72 per cent of the farmers observed the safe-seeding dates, our results may be considered 80 per cent effective. In this case, the results would be 80 per cent effective whether or not the hessian fly outbreak developed.

It is not necessary to set up the same goal for all classes of growers. For instance, commercial fruit growers in a highly competitive area might be justified in producing more than 90 per cent clean fruit, whereas smaller operators classed as general farmers and producing for home use might be warranted in producing only 80 per cent clean fruit. Consequently, our efforts may be as effective in one case as the other, even though the percentage of clean fruit varies.

In conclusion, it may be stated that the method of measuring results need not be the same for all practices, but in order to decide the merits of our various projects and in order that our superiors and budget directors may justify our work to the satisfaction of the public, we must measure our results in some way.—12-22-38.

Human Characteristics We Must Observe in Entomological Extension Work

A. B. GRAHAM, *U. S. Department of Agriculture, Extension Service*

In our extension work subject matter means comparatively little until we can hitch it to some human want, interest, attitude or emotion. To do this the teaching tools which we use must appeal to some characteristics of the individual. If his situation is such that he is annoyed and if what we present contributes still more to his annoyance, the subject matter has fallen flat but if, through our consideration of his annoyances, what we give of subject matter removes them and

sets up a satisfaction in his mind and causes a change in his act for his betterment, then we have taught him something, for teaching must be measured in terms of acts and attitudes.

The great variety of teaching tools which have been discussed at this symposium is for the purpose of setting up these changes through recognizing wants, particularly through three different avenues—the eye, the ear and the hand. Every teaching tool we use can be classified under one of these three: a talk with word pictures for the ear; a circular letter or bulletin and exhibit with their pictures and drawings for the eye. Any form of expression in which the hand, or even the whole of the body takes place, is an appeal to the hand or to any of the tactile nerves and muscles. This in part, develops confidence as to manipulation. We say of the colt which has learned to be guided because of a pull on the right or left of the bit that he is "bit wise" or that he has been broken. So it is with participation or with manual mindedness, we learn by putting our nerve and muscular system into the performance. Try classifying all of the tools you use under the three heads referred to above.

Now, there are about five characteristics of human nature that we have to overcome. Each one of them or a combination of any of them seems to be nearly insurmountable. These are fear, prejudice, tradition, superstition and habit fixation. Fear develops in one when he thinks that he may not know as much as someone else, that he will be thought a "book farmer," or that he may be jeered or smiled at if he accepts some new practice. Prejudice comes because of his thought that any sort of poison bait may kill the birds, that the livestock may die from eating bait or that some neighbor has said the material is not worth anything anyway. Superstition reigns when the time of planting or any control measure must be regulated by the moon or other signs. Tradition plays its part when people pride themselves on living in a locality that never carried on certain practices or when they think "the Lord will provide." Fixation of habit is one of the very strongest to be overcome because we direct our acts in keeping with nerve and muscular ease, and to acquire a new habit time and patience and much effort are required to replace the old growth with the new. Correct subject mattter is necessary but without due consideration of the interesting characteristics referred to above, it may be like the proverbial water on a duck's back.—12-22-38.

Biology and Control of the Pea Weevil in the Palouse Area of Idaho and Washington[1]

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The growing of dried peas for seed and commercial purposes has become a very profitable source of agricultural income in the Palouse territory of Washington and Idaho. At times, however, the crop is seriously damaged by the pea weevil, *Bruchus pisorum* (L.). The insect, through its feeding, makes the peas undesirable for human consumption; can reduce the germination to practically nothing, thus making the peas unfit for seed purposes; and renders the peas less valuable as stock feed.

[1] Abstracts of Iowa State College Doctoral Thesis No. 304, submitted in partial fulfillment of the requirements for the degree of doctor of philosophy. Data presented were accumulated prior to the crop season of 1935.

The methods suggested to control the pea weevil are varied and many in number, but the constant reports of the damage done by the pest point to their inadequacy. Whitehead (1930) points out that the control measures recommended must be fundamentally wrong, for the insect has never been properly controlled. A summary of the results of certain experiments on the control of this pest, together with data on the biology gathered in connection with these studies, is given herein.

LIFE HISTORY.—Weevils that emerge in the fall from peas shattered on the field have been found to survive the win-

ter in a number of widely different situations. Chief among these are loose bark on trees, cracks in fence posts, debris beneath pine trees and brushy fence rows, crevices in stumps, beneath shingles and loose boards on buildings, in pea vines stacked for hay and in unharvested vines left uncut on the pea fields. Practically any cover that affords protection may be utilized by the pea weevil as a hibernating shelter.

Adult insects were found to be capable of passing two winters and one crop season in a state of inactivity, at the beginning of the second crop season emerging and laying fertile eggs.

In the spring the first adult pea weevils appear on the vines about the time the earliest planted peas begin to bloom. These insects feed on the pollen of pea blossoms for a period of 4 to 14 days. During this time the adults mate, and when the developing pods appear the females are ready to begin egg deposition. A maximum of 735 eggs, a minimum of 92 and an average of 432 were recorded from 12 individuals studied. The maximum oviposition period was 83 days, the minimum 17 days and the average 47 days. Eggs were laid on the pea pods from the time they were first visible until they had begun to harden. Alaska peas seeded early in the season were susceptible to attack for 30 days, while those planted late in the season were suitable for egg deposition for only 8 days. The number of eggs laid per pod was limited only by the weevil population present.

A portion of the data from the life cycles of 779 individuals reared from egg to adult is presented in table 1.

Studies indicated that the weevils emerged under field conditions if the peas were undisturbed.

Two parasites, *Microdontomerus anthonomi* Cwfd. and *Eupteromalus* sp., were found. Parasites and predators, however, appeared to have little influence on weevil populations.

In a study of the influence of weevil development on germination, the germination of 100 per cent weevil-infested seeds varied from 98.0 per cent to 0.0 per cent, depending upon the stage of development at the time of fumigation. Weevil-infested seeds that were 100 per cent infested lost 22.4 per cent of their initial weight as a result of larval feeding.

FACTORS INFLUENCING ABUNDANCE.—The shattering of ripe peas due to climatic factors, such as wind, hail and rain, and the loss occasioned by harvesting constitute the most important sources from which pea weevils that infest the crop are recruited. Of these the loss caused by harvesting is the most serious, for it permits large numbers of weevils that otherwise would be sacked and later killed by fumigation to find suitable hibernating quarters. The maximum loss per acre was found to be 50 per cent of the possible yield, on a field from which the peas actually harvested averaged 690 pounds per acre. The minimum loss was 7 per cent, on a field from which 1,428 pounds of peas were harvested per acre. Much of this loss was no doubt due to careless harvesting, for the same growers always suffered the heaviest losses.

Shattered peas often produce volunteer peas in winter wheat, and during some years these volunteer peas develop into producing vines. When this happens, large numbers of insects complete their

Table 1.—Summary of life history data on 111 pea weevils reared in Alaska peas, Moscow, Idaho, 1933.*

Stage	Observation Date		Length of Stage, Days			Statistical Constants, Days	
	First	Last	Maximum	Minimum	Average	Modal Class	Deviation
Egg	July 1	July 12	11	5	9.1	9	1.22
Larval	July 6	Aug. 20	40	29	32.1	31	1.69
Pupal	Aug. 7	Sept. 3	16	8	11.1	11	1.42
Total Life Cycle			65	47	52.3	52	2.65

* Development observed under field conditions up to the pupal stage, and then under field insectary conditions.

development in these peas and consequently serve as an important source of infestation of next season's crop. Observations on 12 of these volunteer patches during 1932 showed an average weevil investation of 71 per cent.

The planting of weevil-infested seed peas was found to be a menace, for as high as 62.7 per cent of the weevils in the peas buried to a depth of 3½ inches, the average planting depth, came to the surface.

EXPERIMENTS ON CONTROL.—Cage experiments to determine the effect of burying weevil-infested peas indicated that few weevils are able to emerge when buried to a depth of 6 inches. In three tests conducted in 1931 an average of 3.8 per cent of the weevils came to the surface.

Field tests in which a plow and a disk were used to bury the peas indicated that 13.8 per cent of the weevils in the peas buried by disking emerged, 2.6 per cent emerged from those that were plowed under to a maximum depth of 9 inches, whereas 61.0 per cent emerged from the same number of infested peas left undisturbed on the soil surface as a check. These data indicate that the plowing under of weevil-infested peas shattered on the ground, prior to and during the harvesting, offers considerable promise as a means of reducing weevil populations built up from this source.

In a study of the time of planting in relation to weevil control, it was found that during 1933 all the plantings were heavily infested, the greatest damage (59.6 per cent) being recorded on the eighth planting. In 1934 there was a decline in weevil infestation after the second planting, but this decrease was more than offset by a decrease in yield.

Field tests in 1933 with calcium arsenate, lead arsenate, sodium fluoaluminate, barium fluosilicate, zinc arsenite and calcium sulfate failed to control the weevil. The dusts were applied at the rate of 20 pounds per acre on 1/40-acre plots. Each dust was applied six times during the crop season.

Laboratory tests were conducted in 1934 with four insecticides: calcium arsenate, barium fluosilicate, a dust containing 0.45 per cent of pyrethrins and a dust containing 1.0 per cent of rotenone in the form of powdered derris root. Adult weevils were placed on blossoms picked from plots that had been treated with these materials at the rate of 20 pounds per acre, dusted weevils were placed on untreated blooms, and weevils forced to walk a distance of 2 inches across a glass surface dusted with each of the materials were placed on undusted blooms.

One application of calcium arsenate or barium fluosilicate, even though thoroughly applied, did not kill all the weevils in 24 hours, whereas the application of derris and pyrethrum dust killed all the weevils. When the materials were applied directly to the weevils, practically the same results were recorded. It is apparent from these tests that derris or pyrethrum dusts may be effective insecticides for use against the pea weevils.

Experiments were begun in 1932 to determine the value of the border trap crop as a method for the control of the pea weevil. Strips of peas 10 feet wide (one drill width) were planted as early as possible about the edge of a field that was to be sown to peas. The main field was seeded with the same variety from two to three weeks later. Records of the movement of the weevil population were obtained by sweeping.

During 1932 the borders were planted and left untreated in the hope that the weevils would exhaust their egg-laying capacities on the border plantings. This was not the case, however, for as soon as the peas in the main field began to blossom the weevils migrated into the field. A maximum of 1,415 weevils was collected in the border in 100 sweeps of a 15-inch collecting net at the peak of the infestation, whereas only 8 were collected in the same number of sweeps adjacent to the border in the main field. The average for the peak in this field was 839 weevils in 100 sweeps in the border and 24 in a like number of sweeps in the main field adjacent to the border.

A heavy weevil population did not develop during 1933, and the borders were again left unmolested. Some infestation developed in the main fields during this season, but it was not serious.

In 1934 the borders about two of the fields were burned by a tractor-powered, generator-type burner constructed by the Bureau of Agricultural Engineering of the United States Department of Agriculture, and the border about the third field was plowed under. This burner was admirably

adapted to the type of terrain over which it was pushed, but in spite of the terrific heat generated it did not scorch the vines and insects sufficiently, and a large number of the adults survived.

The results with plowing were more favorable. Previous to plowing, 439 weevils were caught in three cages, each covering 36 square feet of surface, whereas after plowing only 8 weevils were caught in cages covering the same area. The peas in the main field remained comparatively free from weevils.

CONCLUSION.—From these results it seems possible that further research on the relationship between the blossoming dates of the border and main field, on the type of plowing equipment used to bury the peas and the use of insecticides in connection with the borders may make the use of border trap strips a valuable adjunct in pea weevil control.—8-10-38.

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The Olfactory Responses of Flies in a New Type of Insect Olfactometer

*II. Responses of the Housefly to Ammonia, Carbon Dioxide and Ethyl Alcohol**

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It is an interesting circumstance that although there is world wide interest in the housefly, *Musca domestica* L., and although a wealth of observation and experiment exists proving that response to volatile substances plays an important part in the fly's feeding and oviposition habits, almost no quantitative data on its chemotropic reactions have been published. Most of the experiments have consisted in counting the number of flies attracted to traps baited with various substances often in process of fermentation or putrefaction (Morrill 1914; Richardson 1916, 1917; Crumb & Lyon 1917, 1921; Laake *et al.* 1931).

Even though various concentrations of a given compound, *e.g.*, ethyl alcohol, are added to a series of baits such a method gives no information on the concentration of the compound in the surrounding air, *i.e.*, the concentration as a gas to which the fly reacts in a positive manner and thereby is induced to approach the bait. In fact this gaseous concentration varies greatly depending upon distance from the bait and air movements. When the fly has once reached the bait, its subsequent feeding or oviposition may be correlated with the concentration of a given substance in the bait but even then its concentration in the gaseous condition in the immediate neighborhood of the bait in all probability still has an influence.

While many compounds and mixtures of known or unknown composition have been offered to houseflies in various baits, interest has centered often in the products of fermentive or putrefactive processes. It is obvious that effects apparently caused by non-volatile substances such as arsenic (Laake *et al.* 1931) or methylene blue (Lodge 1918) are due to alteration in the chemical reactions occurring in the bait when such compounds are added. For several years the effects of carbon dioxide and of ammonia as attrahents and stimuli for oviposition by the housefly were in dispute between Richardson (1916, 1922) and Crumb & Lyon (1917, 1921). The former found ammonia to be the chief attrahent from decomposing organic matter, including manure, whereas the latter stated that carbon dioxide is the chief attrahent at least for egg laying and they

* Contribution from the laboratory of insect physiology and toxicology, Division of Entomology and Parasitology, University of California.

suggested that the fly's preference for decaying vegetable matter rather than animal matter may have its explanation in that fact. Ammonia was found to be actually repellent. In none of these experiments was the concentration of any of the gases known. The other prominent product of fermentation, ethyl alcohol, was found to be attractive at concentration between 3 and 8 per cent in aqueous solution (Buck 1915). A concentration of 4 per cent was found by Richardson (1917) to be more attractive than 10 per cent. It is likely that many successful baits containing beer, stout or other liquors owe their attractiveness in part to alcohol. In these experiments also no information was gained regarding the concentration of vaporized alcohol in the atmosphere about the traps.

A study of the available information on the chemotropisms of the housefly indicated that many of the divergent conclusions reached by different workers were due to failure to take into account the varying concentrations as a gas of the substances under test. This opinion was strengthened by results of the work on the reactions of fleshflies to repellents which has been in progress in this laboratory for several years. Not only does the effect of a given compound vary with its concentration but an initial attraction may change to strong repellence at a higher concentration (Hoskins & Craig 1934).

Studies of this nature can be made only in some kind of an olfactometer and accordingly it was decided to try houseflies in the apparatus mentioned in the above citation. This may be described briefly as a box in one side of which are two closely adjacent circular holes covered with wire screen, called the test and check areas. Beyond these are two long funnels which serve as inlets for two streams of air, one of ordinary composition and the other containing a known concentration of the gas which is being studied. The incoming gases are withdrawn through outlets in the floor near the entry ports in order not to contaminate the whole chamber and thus decrease the concentration gradient. Beyond the funnels is set a light which attracts fleshflies to the ports. Counts of the numbers on the test and check areas are made at stated intervals for a certain period, and from the sums the average attraction or repulsion is calculated.

REARING OF HOUSEFLIES.—Fly larvae were reared in battery jars upon the bran-alfalfa meal mixture recommended by Richardson (1932). These were kept at 32 degrees C. The adults were kept in cages at 25 degrees C. and fed upon a casein-yeast-sugar mixture with water always available. When eggs were desired, a jar of the larval food was placed in a cage until enough eggs had been laid. Overcrowding was avoided, for this results in small flies whose reactions are found not to be normal, as was reported also by Deonier & Richardson (1935) for another kind of chemoreaction.

All tests were made with flies 5 to 10 days old. Since food was present continuously it may be assumed that all or nearly all the females had been fertilized and were ready to lay eggs (Bishopp, Dove & Parman 1915). Materials on which eggs are ordinarily laid was excluded from the cages, however, so all tests were made before the females had deposited their eggs. Except when the sexes were separated purposely, mixed populations were used. Numerous counts showed the average sex ratio to be close to unity. When it was desired to separate the sexes a group was chilled until the flies were motionless and the individuals were examined individually. No harm appeared to result from this treatment, for all recovered and behaved normally afterward.

ADAPTATION OF THE OLFACTOMETER TO HOUSEFLIES.—As originally designed for fleshflies the olfactometer depended upon light stimulus to bring the flies to the test and check areas (Hoskins & Craig 1934). Houseflies are but slightly attracted to light, and a few trials showed that they remained dispersed about the olfactometer chamber or congregated in accordance with their gregarious nature in various regions of the chamber. Trials with various colors and intensities of light led to no satisfactory response. This is in agreement with the results of J. K. Ellsworth of this Division of Entomology, who has found no light satisfactory for bringing houseflies to an electrocutor.

It has been noted that houseflies select warm parts of a manure pile to lay their eggs (Bishopp, Dove & Parman 1915) and

that they assemble in regions in which the temperature is 42–44 degrees C. (Lodge 1918) or 34–41 degrees C. (Nieschulz 1935). In order that this thermotropism might be used in the olfactometer, streams of air heated to various temperatures were introduced through the ports to determine that which brought the largest percentage of houseflies to them. Air from out of doors went through a pump lubricated by a heavy, highly refined mineral oil, through a long cotton filter pad to eliminate all oil spray, through several feet of glass tubing in a heating chamber to bring it to the desired temperature and finally to the ports in the side of the olfactometer. A **Y** junction and flowmeters were included in the line so that two air streams of the same velocity as well as temperature could be brought to the ports.

The heating chamber is an air bath equipped with a thermoregulator, fan and 75-watt lamp which is painted black to prevent any possible effect of its flashing upon the flies. A small steady heat and sufficient illumination to permit counting of the flies is given by a 25-watt lamp set symmetrically between the small ends of the two funnels. Except as they project through the walls of the heating and the olfactometer chambers the funnels are entirely within the heating chamber. They are made of *Pyrex* glass, $1\frac{1}{2}$ inches in diameter at the ports, and are drawn down evenly over a length of 12 inches and fused to 5-millimeter tubing at the small ends. While it might be assumed that this arrangement would result in the whole of the areas being filled with moving air of the same temperature, this was checked by placing small copper-constantan thermocouples at various points of the areas.

Several temperatures in the interval from room conditions (about 18 degrees C.) to 50 degrees C. were tried. In each case the two air streams were at the same temperature, *i.e.*, no attempt was made to find an optimum by direct comparison. The criteria used were per cent of the total population responding to the two ports and behavior of the flies in these regions and elsewhere in the olfactometer. The results may be summarized for three intervals comprising the whole temperature range used. In the lower interval (18–30 degrees C.) there was little attraction to the moving air and the flies moved about the whole olfactometer in typical lively manner. In the next interval (31–41 degrees C.) attraction to the moving air increased and activity was sufficiently great so that the flies moved about freely; at 42–50 degrees C. attraction decreased and heat paralysis was increasingly prevalent. This was very objectionable for it eliminated the possibility of multiple choice by the flies and thereby impaired the effectiveness of the test (Hoskins & Craig 1934). High response and normal activity seemed to prevail best at 41 degrees C., and accordingly this temperature was selected for the tests with gases added to one air stream.

It was necessary also to determine the most favorable air speed. When this was low the flies responded poorly probably because the warm air turned upward as it entered the olfactometer and collected in the top. When the air entered rapidly the flies on the test and check areas fluttered their wings and held fast to one spot. The most favorable air flow according to the criteria of adequate response and normal activity of the flies was about 7.2 cubic feet per hour. A calibrated flowmeter was used in each air line to insure constancy. At this rate of flow through the ports of the olfactometer the motion of the air is just perceptible to the hand.

A third factor of possible importance was the humidity of the air streams. Experiments were made with dry and saturated air versus ordinary air. In both cases the latter was preferred. A study of the results obtained throughout the investigations which lasted several months shows no detectable effect of the normal alterations in water content of the outside air. Hence it was concluded that for the present purposes no attention need be paid to it.

To control the concentration of a gas added to the air stream a calibrated flowmeter was used to measure the rate at which it entered the air stream. In the case of liquids the general procedure has been used of determining the loss of weight of the liquid from a bubbling chamber held at 25 degrees C., when a measured volume of nitrogen was passed through it. This saturated stream of nitrogen was then mixed in the desired pro-

portion with the air going to the test area. If care is taken to insure saturation of the nitrogen the concentration may be calculated from the vapor pressure of the liquid whenever that is known.

The complete olfactometer with accessory apparatus is shown and labeled in fig. 1. It may be noted that it retains the advantages of the original instrument, *e.g.*, insects may fly or crawl as they wish; chamber. After waiting five minutes to insure adequate response 10 counts of the number of flies on each area were made at one minute intervals. Five lots of flies were used in this way with the test gas entering at one port. The lines were then flushed with outside air, the gas was sent through the other port and five more lots of flies were tested. In this way any effects of position were minimized.

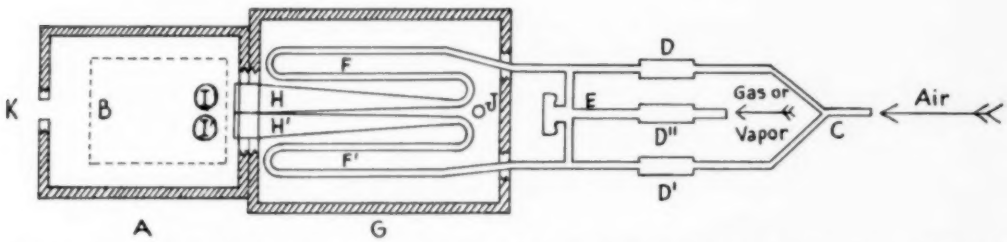

FIG. 1.—Diagram of olfactometer adapted for use with houseflies. A, olfactometer chamber, 12×10×8 inches deep; B, wire screen cage; C, Y tube; D, D′ and D″, flowmeters; E, three-way stopcock for sending gas to desired port; F and F′, glass tubing in heating chamber, G; H and H′, long funnels leading to ports in side of olfactometer chamber; I and I′, exhaust ports; J, 25-watt light; K, observation hole.

a high percentage of the total population responds; there is opportunity for multiple choice, which means that with a lively insect such as the housefly the same individual may be counted several times on each area so that a real average behaviour is determined and the effects of the gregarious instinct are reduced to a minimum; the test requires only a short time; a high gradient of known and controllable concentration is maintained between the test and check areas. On the other hand certain disadvantages should be mentioned: the temperature 41 degrees C. corresponds to a very warm day and the behavior at lower temperatures may be different; a short delay before a high percentage of the population assembles at the test areas might result in toxic effects when a very poisonous gas is used and consequently a smaller percentage would respond; on very dark days in the winter response to the warm air streams was always low.

The routine procedure may be summarized briefly at this point. When all adjustments of temperature, rate of flow and concentration had been made, 20 to 25 flies, 5 to 10 days old, were transferred from the large cage to a small wire screen cage which fitted inside the olfactometer

EXPERIMENTS WITH AMMONIA, CARBON DIOXIDE AND ETHYL ALCOHOL.—The ammonia and the carbon dioxide were commercial products of approximately 99 per cent purity, in which the contaminants were chiefly atmospheric gases and water. The alcohol was the so-called "absolute grade" which contains about 1 per cent water. Corrections for these departures from 100 per cent purity of composition were not made since they would be entirely negligible in comparison with the unavoidable experimental errors and biological variations of the insects used.

The average results of many trials with several concentrations of each of the materials are given in table 1. It is obvious that ammonia is an example of those substances which are attractive over a limited range of low concentration but are strongly repellent at higher concentrations. No attempt was made to determine the threshold of reaction but it apparently is slightly below 0.006 per cent NH_3 by volume. At the temperature used (41 degrees C.) this corresponds to 0.04 milligrams NH_3 per liter. It is interesting that the least concentration detectable by most humans is 0.0053 per cent (McNally 1937). Apparently man and housefly are about equally sensitive to ammonia. The

concentration of 0.15 per cent (1 milligram NH_3 per liter) drove almost all flies from the test area. Again, this is about the maximum concentration which can be tolerated by humans for even a short period (McNally 1937). Trials with the separate sexes showed that while both are attracted to low concentrations of ammonia, this reaction is much more pronounced in the case of females. In all cases, whether or not added substances were present in the test air stream, the separate sexes were more nearly uniform in behavior than mixed groups. However, the average distribution of mixed groups is not controlled by the reactions of either sex for, as shown in table 1, the average

Table 1.—Response of houseflies to various concentrations of ammonia, carbon dioxide and ethyl alcohol.

Substance	Per Cent Concentration by Volume in Air Stream	Per Cent Response		
		Mixed Group	Females	Males
Ammonia	0.0060	52.6	—	—
	0.0120	64.6	77.9	60.7
	0.0360	40.3	47.8	35.7
	0.0960	20.5	—	—
	0.1500	2.9	—	—
Carbon dioxide*	0.0120	48.6	49.1	46.9
	0.0360	49.5	53.6	47.4
	0.0960	50.3	—	—
	0.1600	50.0	—	—
	2.7000	46.5	—	—
	3.9000	42.3	—	—
Ethyl alcohol	0.0063	50.9	—	—
	0.0126	57.9	48.4	57.7
	0.0340	51.6	31.4	67.7
	0.1590	39.4	—	—
	0.3360	26.3	—	—

Temperature 41 degrees C. In all cases the check was a stream of uncontaminated air at the same temperature. Above 50 per cent indicates attraction; below 50 per cent indicates repulsion.

* All concentrations are in addition to that naturally present in the air, which was a few hundredths of 1 per cent.

of the male and female distributions is very close to that of the whole group in all but one of the conditions in which such a comparison can be made.

Ammonia is somewhat toxic to insects and it is very irritating to man and animals. Hence it was of interest to determine whether any decided change in reaction of the flies occurred during a period somewhat longer than the regular observation period. Ten lots were exposed to 0.012 per cent NH_3 and counts of distribution were made each minute for 20 minutes. The average percentages going to the ammonia of those that responded were 64.2 per cent (1–5 minutes), 64.8 per cent (6–10 minutes), 64.5 per cent (11–16 minutes) and 60.4 per cent (16–20 minutes). After the first few minutes about 80 per cent of the group continued to be present upon the test and check areas at all times. These results indicate a very steady response to this attractive concentration of ammonia.

Carbon dioxide is present in the atmosphere to the extent of a few hundredths to several tenths of a per cent depending upon the locality. Since the check air stream contained the carbon dioxide naturally present, it is to be expected that no pronounced reaction would be caused by low concentrations in the test stream. The surprising result is the almost entire lack of attraction for either sex at any concentration used.

Ethyl alcohol is mildly attractive to mixed populations at a low concentration (0.0126 per cent by volume at 41 degrees C. equals 0.23 grams C_2H_5OH per liter). At higher concentrations it is mildly repellent. The males are rather strongly attracted to low concentrations, but females are repelled.

Discussion.—The idea that an insect's response to a substance in the gaseous state will vary with its concentration is certainly not new but little use has been made of this conception in experimental work on chemotropism. It is probable that disagreements, such as that between Crumb & Lyon on the one side and Richardson on the other regarding the effects of ammonia and carbon dioxide, may be cleared up, at least in part, by quantitative data on insect reactions to different concentrations of the substances concerned. In this particular case the results of the present investigation may be considered to strengthen Richardson's claim that ammonia is a stimulus to oviposition, if the assumption be made that the congregation of females at a locality will result in more eggs being laid there, all other conditions being equal.

The simple and direct method of controlling concentration in the gaseous phase by use of flowmeters offers a means

for studying the reactions of organisms to known concentrations of nearly any kind of substance. Gases may be measured directly and a stream of an inert gas such as nitrogen may be saturated with a liquid and then measured in the same way. Both these methods are being used in this and other investigations now under way. Even solids may be used if they are finely divided and the gas which is passed through them is given the opportunity to come to some steady state, which need not be saturation.

In order to forestall a possible erroneous conclusion it should be mentioned that the temperature, 41 degrees C., which was used in the tests was not that to which houseflies go in largest numbers when given their choice of a range of temperature. The so-called "optimum temperature" was found in separate investigations. This was determined by sending heated air through *short* funnels on to the wire ports. Under these conditions the whole port is not filled with air of the same temperature but the central region is warmest and concentric rings of equal temperature surround it. When air at successively higher temperatures up to and including 43–44 degrees C. was sent through the port the flies continued to congregate in the center. At 44–45 degrees C. they moved away into a small ring and at higher temperatures moved successively further away from the center. This result agrees with that of Lodge (1918) secured in an entirely different way, and shows that the temperature preferred by houseflies is the same whether obtained by radiation or by moving heated air. At this temperature the flies are sluggish and accordingly 41 degrees C. was more suitable for the olfactory tests.

SUMMARY.—An olfactometer suitable for use with houseflies is described. It depends upon streams of air heated to 41 degrees C. to attract the flies to the test and check areas. Concentration of the substance to be tested is controlled by the use of flowmeters and saturating chambers. The results show that mixed groups having a sex ratio of approximately unity are attracted to ammonia at a concentration of 0.012 per cent by volume but are strongly repelled at concentrations greater than 0.03 per cent. Carbon dioxide has no appreciable effect up to about 2 per cent. Ethyl alcohol attracts feebly at 0.012 per cent and repels above about 0.05 per cent. With separated sexes, females are more strongly attracted than males to ammonia and the reverse is the case with ethyl alcohol.—8-10-38.

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The Effect of Temperature Upon Egg Deposition, Egg Hatch and Nymphal Development of *Paratrioza cockerelli* (Sulc)

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The entomologist, and in general the layman, accepts the fact that low winter temperatures are often a determining factor in the abundance and distribution of many economic species of insects, but apparently few in the North, especially, give much thought to a possible retarding influence of summer temperatures. Several years of field observations of the psyllid, *Paratrioza cockerelli* (Sulc), the most serious pest of tomatoes and potatoes in Colorado, indicate that this species is especially affected by summer temperatures and may be considered a low-temperature species. This is indicated by the rather intermittent outbreaks that occur in certain localities, the seriousness of the pest in the cool, high mountain areas and its frequent, almost complete, disappearance during the hotter part of the summer from some of the warmer areas.

The studies herein reported were carried out during the winter of 1935–36 in an effort to measure the effect of certain temperatures and combinations of temperatures. The data are not complete but, since the project has been discontinued, it seems advisable to present them with the hope that others may carry the study further.

EXPERIMENTAL METHODS AND EQUIPMENT.—Temperature studies were made in glass top thermostatically controlled incubators of about 2 cubic feet capacity. The incubators permitted not more than 2 degrees† fluctuation. They were so ventilated that the humidity did not vary greatly from that of the greenhouse in which all except the 60-degree and 70-degree series were kept.

The greenhouse was planted largely to tomatoes which were being grown for psyllid studies. The humidity and temperature in the house proved to be favorable for the psyllid since all plants became very heavily infested. The mean daily temperature of the house, over a three-weeks period, varied from 59 degrees, one cold day, to 74 degrees. The average of the daily mean temperatures was 66.2 degrees. The highest temperature during the period was 81 degrees. The checks were cages carried under these conditions, unless otherwise stated. As the adults used in making the records given in table 1 were taken at random in the greenhouse, they were of varying ages; those used in the cages, for which data are given in table 2, were collected shortly after emergence while still soft and uncolored. At first the cages used to confine the adults on plants for egg deposition were lamp chimneys covered with gauze, but wire cages were used later to avoid a different humidity condition than existed in the greenhouse.

In the study of the effect of temperature upon egg hatch, adults were allowed to deposit on tomato plants in cages at either greenhouse temperature or 80 degrees constant; subsequently these plants were all placed in the incubators. As the adults do not deposit readily the first day or two after being caged, it was occasionally necessary to keep the plants in the oviposition cages for three to four days, in order to have the desired number of eggs. Thus the temperature effect was not always for the entire incubation period.

EFFECT OF TEMPERATURE UPON EGG DEPOSITION.—Tables 1 and 2 give the number of eggs deposited under different temperature conditions.

From the temperatures studied, it appears that 80 degrees is near the optimum. In fact, 80 degrees constant temperature gave such good results in egg deposition that it was often used when a supply of eggs was desired. Because of the time required in counting accurately the large number of eggs, extensive records with this temperature were not taken. Eggs were deposited freely at 70 degrees constant temperature. It took the newly emerged adults one day longer to start egg laying under 70 degrees than under 80 degrees, but otherwise this temperature seemed to be almost as favorable as 80 degrees. While only one cage was car-

* The writer is indebted to Gordon Mickle and Leonard Sweetman for assistance in taking parts of the data.

† All temperatures are given in Fahrenheit.

Table 1.—Effect of temperature upon egg deposition and length of life of adults of *Paratrioza cockerelli* (Sulc) collected at random.

TEMPERATURE	NUMBER OF ADULTS	DAYS TILL DEATH OF LAST ADULT	NUMBER OF EGGS	EGGS PER ADULT
60 degrees constant	25	33	108	3.25
70 degrees constant	25	22	242	11.00
80 degrees constant	25	*	657	26.28
90 degrees constant	25	10	1	0.04
90 degrees constant	25	6	115	4.60
90 degrees constant	25	11	21	0.84
90 degrees 9 hours; 80 degrees, 15 hours	25	16	866	34.64
90 degrees 9 hours; 80 degrees, 15 hours	25	13	700	28.00
100 degrees constant	25	9	0	0.00
100 degrees constant	25	4	0	0.00
100 degrees 9 hours; 80 degrees, 15 hours	25	7	0	0.00
100 degrees 9 hours; 80 degrees, 15 hours	25	11	102	4.08
100 degrees constant (wire cage)	20	4	45	2.25
100 degrees constant (wire cage)	15	6	28	1.86
100 degrees constant (wire cage)	25	3	0	0.00
100 degrees constant (wire cage)	30	5	0	0.00
100 degrees, 5 hours; 80 degrees, 19 hours	25	12	75	3.00
100 degrees, 5 hours; 80 degrees, 19 hours; wire cage	20	10	200	10.00
100 degrees, 2 hours; 80 degrees, 19 hours; wire cage	30	12	175	5.83
100 degrees, 2 hours; 80 degrees, 22 hours	25	8	160	6.40
100 degrees, 2 hours; 80 degrees, 22 hours	20	7	100	5.00
100 degrees, 2 hours; 80 degrees, 22 hours	25	8	230	9.20

* These eggs deposited in 8 days; 20 adults alive at that time. Complete record not taken.

ried at 60 degrees it is sufficient to indicate that eggs may be deposited freely at that temperature.

When the 90-degree records are examined, it is apparent that a very marked reduction in eggs has occurred. The 80 newly emerged adults (table 2), carried in 4 cages at this temperature, deposited only 25 eggs. The 75 adults of varying ages deposited only 137 eggs. They deposited most of these the day of caging.

Ninety adults caged at 100 degrees constant temperature deposited only 73 eggs, all the first day. Incidentally, they deposited all of these in wire cages where the humidity was undoubtedly lower than in the glass.

To determine whether 90 degrees and 100 degrees for only parts of the day were injurious, a number of cages were alternated between these temperatures and 80 degrees. Fifty adults held at 90 degrees for 9 hours and 80 degrees for 15 hours oviposited much more freely than those held at 90 degrees constant, but not so freely as those held at 80 degrees constant.

In all cases, 100 degrees for even part of the time greatly retarded egg laying. When this temperature was maintained for nine hours, 50 adults deposited only

Table 2.—Effect of temperature upon egg deposition and length of life of adults of Paratrioza cockerelli (Sulc) caged upon emergence.

TEMPERATURE	NUMBER OF ADULTS	DAYS BEFORE EGG DEPOSITION	DAYS TILL DEATH OF LAST ADULT	NUMBER OF EGGS
70 degrees constant	25	4	Not determined	550 in 7 days
80 degrees constant	15	3	Not determined	600 estimated 7 days
90 degrees constant	25	6	7	25
90 degrees constant	25	0	12	0
90 degrees constant	15	0	3	0
90 degrees constant	15	0	5	0
100 degrees, 5 hours 80 degrees, 19 hours	25	0	3	0

Table 3.—Effect of temperature upon egg hatch and larval development of *Paratrioza cockerelli* (Sulc) 1936.

TEMPERATURE	NUMBER OF TESTS	TOTAL EGGS	TOTAL HATCH	PER CENT HATCH	TOTAL MATURED	PER CENT EGGS PRODUCING ADULTS	PER CENT LARVAE MATURING
100 degrees constant	2	299	5	1.67	0	0.00	0.00
100 degrees, 9 hours 80 degrees, 15 hours	2	137	0	0.00	0	0.00	0.00
100 degrees, 4 hours 80 degrees, 20 hours	4	2,170	243	11.19	0	0.00	0.00
100 degrees, 4 hours Greenhouse, 20 hours	14	2,084	75	3.59	0	0.00	0.00
100 degrees, 3 hours 80 degrees, 21 hours	3	3,490	149	4.26	0	0.00	0.00
100 degrees, 3 hours Greenhouse, 21 hours	10	2,033	33	1.62	0	0.00	0.00
100 degrees, 2 hours 80 degrees, 22 hours	9	2,655	90	3.38	0	0.00	0.00
100 degrees, 2 hours Greenhouse, 22 hours	16	1,220	125	10.24	0	0.00	0.00
100 degrees, 1 hour Greenhouse, 23 hours	6	3,351	462	13.78	21	0.62	4.54
Check for all 100 degrees tests	7	1,642	723	44.03	660	40.19	91.28
95 degrees, 8 hours Greenhouse, 16 hours	5	1,588	118	7.11	19	0.11	16.81
Check for 95 degrees, 8 hours	1	315	252	80.00	237	75.23	94.04
95 degrees, 6 hours Greenhouse, 18 hours	6	2,044	389	19.03	270	13.20	69.40
Check for 95 degrees, 6 hours	1	179*	183	100.00	183	100.00	100.00
95 degrees, 4 hours Greenhouse, 20 hours	6	3,474	1,750	50.37	756	22.18	43.20
Check for 95 degrees, 4 hours	1	957	615	64.26	568	59.35	92.35
95 degrees, 3 hours Greenhouse, 21 hours	6	1,840	957	52.01	294	15.97	30.73
Check for 95 degrees, 3 hours	1	340	287	84.41	220	64.70	76.65
95 degrees, 2 hours Greenhouse, 22 hours	6	2,683	1,945	72.49	769	28.66	39.53
Check for 95 degrees, 2 hours	1	340	287	84.41	220	64.70	76.65
90 degrees constant	6	976	310	32.05	0	0.00	0.00
90 degrees, 9 hours 80 degrees, 15 hours	2	724	362	50.00	0	0.00	0.00
80 degrees constant	1	16	10	62.50	10	62.50	100.00
60 degrees constant	2	156	63	40.38	3	0.19	4.76
All checks	12	3,433	2,060	60.00	1,868	54.41	90.68

* Evident error in counting.

2 eggs each. At 100 degrees for five hours, 130 adults averaged 3.9 eggs, and at 100 degrees temperature for two hours per day, adults averaged 7 eggs each. Estimates, based on rough counts, of the eggs deposited by adults collected at random and held in cages at 80 degrees and at greenhouse temperatures were well over 100 per adult.

It is interesting to note that when the adults were exposed to 100 degrees they became very restless, often leaving the plant and crawling nervously over the cage. When such temperatures are reached in the greenhouse the same restlessness appears, resulting in many adults flying to the glass or ventilators.

EFFECT OF HIGH TEMPERATURES UPON LENGTH OF LIFE OF ADULT PSYLLIDS.—The higher temperatures greatly reduced the length of life of the adults. At 80 degrees constant and at greenhouse temperatures, numerous adults were active and laying eggs after 20 and 30 days in the same type of cages as used with the high temperatures, whereas even the 90 degrees

reduced the length of life very materially. Under conditions of 100 degrees for a part of the day the greatest mortality occurred on the second and third days, with few living as much as 6 to 10 days. As shown in table 2 the greatest length of life of 55 newly emerged adults exposed to 100 degrees for five hours was seven days. There was no material difference in the length of life in the screen and glass cages.

It is interesting to note from table 2 that egg laying began sooner with the newly emerged adults under 70 degrees and 80 degrees than under 90 degrees of temperature.

EFFECT OF TEMPERATURE UPON EGG HATCH AND NYMPHAL DEVELOPMENT.—Table 3 gives the results of 118 tests of various temperatures and combinations of temperatures upon egg hatch and nymphal development of the psyllid. A total of 34,713 eggs was used in the tests. The results serve to explain numerous field observations where heavy egg deposits have failed to produce the infestation indicated.

It will be noted that 100 degrees is very detrimental to egg hatch even when maintained only one and two hours. The 100 degree temperature was used in a total of 66 tests, involving 17,349 eggs. It probably should be mentioned again that the embryos in many of these eggs were partly developed when exposed to these temperatures. The highest percentage hatch was 13.78 when the eggs were exposed to 100 degrees for only one hour per day. The effect of 100 degrees upon nymphal development was just as pronounced. From the 17,439 eggs only 21 nymphs developed to maturity and these were exposed to 100 degrees for only one hour each day. These represent only 0.6 per cent of the 3,351 eggs in those particular tests and only 4.54 per cent of the 462 nymphs that hatched.

A total of seven checks, carried under greenhouse conditions, was used for the 100-degree series, involving 1,642 eggs, 44.03 per cent of which hatched. Of the 660 nymphs, 91.28 per cent matured in contrast with the 4.5 per cent in the case of the one-hour exposure to 100 degrees. Forty per cent of all eggs in the check produced adults.

A temperature of 95 degrees was also found to be very detrimental to both egg hatch and nymphal development. Of 1,588 eggs exposed to this temperature for eight hours each day, only 7 per cent hatched, whereas 90 per cent of the check hatched. Of the 113 nymphs exposed to the same temperature for the same length of time, 16.8 per cent matured, in comparison with 94 per cent of the check. Only 0.11 per cent of the eggs exposed to 95 degrees for eight hours produced adults, as compared with 75 per cent for those in the check.

A temperature of 95 degrees for six hours was not so detrimental. Here 19 per cent of the eggs hatched and 69 per cent of the nymphs matured. Thirteen per cent of the eggs produced adults in comparison with 100 percent in the check. With 95 degrees for four hours, 22 per cent of 3,474 eggs produced adults in contrast with the 59 per cent from the check. The deleterious effect was shown on both egg hatch and larval development.

Ninety-five degrees for three hours per day permitted 52 per cent of the eggs to hatch in contrast with 84 per cent of the check, and 31 per cent of the larvae to mature, whereas 77 per cent of those in the check matured. The percentage of eggs producing adults was 16 at 95 degrees and 65 in the check.

Ninety-five degrees for only two hours made little difference in the egg hatch, but only 40 per cent of the eggs produced adults, in comparison to 77 per cent for the check. It would appear that a temperature of 95 degrees for only two hours per day is injurious to the nymphs since only 29 per cent of the 769 matured.

Even 90 degrees as a constant temperature was injurious, only 32 per cent of 976 eggs in six tests hatching; none of the 310 nymphs matured. Ninety degrees for 9 hours resulted in a 50 per cent hatch of a total of 724 eggs, but none of the 362 nymphs matured.

With 80 degrees constant temperature the percentage of egg hatch, as well as percentage of nymphs maturing, was slightly above these percentages averaged for all checks. Sixty degrees constant temperature reduced the egg hatch about one-third, while the number of nymphs maturing was influenced even more adversely. These results are compared with the 12 checks where 60 per cent of 3,433 eggs hatched followed by maturity of 91 per cent of the 1,868 nymphs.

CORRELATION OF EXPERIMENTAL RESULTS WITH FIELD OBSERVATIONS.—These effects of high temperature upon the development and possibly the activities of *Paratrioza cockerelli* (Sulc) help to explain certain field conditions. For instance, in the extreme southern part of its range, the insect can be considered a winter breeding species, disappearing almost completely with the coming of high temperatures. A somewhat similar condition exists in the Grand Valley of Colorado. In this area, heavy populations on early potatoes, that are planted as soon as freedom from frost will permit, are of almost annual occurrence, making potato growing very hazardous unless control methods are carefully followed. Yet the practice in the Fruita section is to plant seed plots shortly before digging time for the early market crops, and these develop without psyllid injury. In fact it is difficult to find the insect during late summer and fall. Tomatoes are grown commercially in this general region without serious injury from the psyllid except occasionally early in the spring. When this occurs the infestation disappears without artificial control.

A study of the records of the Grand Valley shows that the temperatures during April, May and part of June are very favorable for the building up of the population that injures the early potatoes, while after the middle of June lethal temperatures are of common occurrence. Table 4 shows the average number of days during an 11-year period with a maximum temperature of 90 degrees or above was 59; 24 of these were of 95 degrees or above and 4 were of 100 degrees or above. The season of 1934 was slightly hotter than the average, with 68 days of 90 degrees or above, 28 of 95 degrees or above and 12 of 100 degrees or above. During the fall of this particular year the writer spent an entire day examining tomato and potato fields in the Valley, finding only one psyllid. This was on a volunteer potato plant in a field of early potatoes which had not been dug, largely on account of psyllid injury. Adjacent to the potato field was a two-acre field of tomatoes that had shown a light early infestation, which had disappeared before serious injury could occur.

A condition exists in the Arkansas Valley of Colorado similar to that in the Grand Valley in that an early spring infestation occurs, but largely disappears with the coming of hot days. Potatoes are not grown here, but the tomatoes usually show an early infestation. The seriousness of the damage is not realized by the growers as the plants largely recover when the feeding stops and the loss is represented by a delayed crop and shorter season. However, in the upper part of the Valley in the Canon City region, the temperatures sometimes permit breeding throughout so much of the season that heavy crop losses result. Just out of the Canon City area in nearby mountain valleys, where lower temperatures prevail, serious losses to potatoes occur almost annually.

On the northeastern Colorado plains area the infestation often damages early potatoes but is usually held in check on the cultivated and wild hosts during the early summer.

After the advent of cool weather in August, it builds up rapidly to a point where serious damage to tomatoes and late potatoes often results. In the Fort Collins area, at an altitude of approximately 5,000 feet, where the writer has studied the insect rather intensively as a tomato pest, it has appeared to be the effect of temperatures upon the hatching of eggs that has had the greatest influence upon the summer population. On a number of occasions when eggs were very numerous the infestation has not developed, due to a failure of the eggs to hatch.* Invariably the infestation builds up rapidly in the tomato fields during the last half of August and the month of September, when lethal temperatures do not occur. Hard freezes and snows usually catch large numbers of all stages of the insect on all hosts that are green.

As shown in table 4 Fort Collins has had only one day of 100 degrees in 11 years. On the average there are only 2.54 days per season of 95 degrees and 15.72 of 90 degrees. In 1936 with 28 days of 90 degrees or above, 7 of these with 95 degrees or above and 1 with 100 degrees, there was a very definite retardation of psyllid development in the experimental plots of tomatoes during July and early

* Glen Hartman reports a definite retarding of psyllid development in certain areas of Wyoming on account of above-optimum temperatures. University of Wyoming Agricultural Experiment Station Bulletin 220. May, 1937.

August, with a very noticeable increase in the population after the middle of August, when the heat wave broke. In 1933, with only 13 days of 90 degrees or above, and only 1 of these having 95 degrees, there seemed to be a steady increase in population throughout the summer, with the result that tomatoes were almost a complete failure. Probably the most general loss of tomatoes occurred in 1927 when there were only four days during which the temperature reached 90 degrees.

The most consistently heavy annual populations occur in the potato-growing areas of 6,000 feet or more altitude. Here, when the spring infestations are present, increase occurs throughout the growing season. A summary of the temperature records of Garnett, in the potato-growing area of the San Luis Valley, altitude 7,576 feet, is given in table 4 as typical. There are only 0.36 days per year during which the temperature reaches 90 degrees, or only 4 days during the 11 years. The average monthly mean maximums for an 11-year period are May, 67.90 degrees; June, 77.94 degrees; July, 80.85 degrees; August, 79.47 degrees; and September, 74.08 degrees, almost optimum temperatures without any days of retarding temperatures.

Table 4.—The average for an 11 year period of the number of days per month and per season having maximum temperatures of 90 degrees and above, 95 degrees and above, and 100 degrees and above for three sections of the state.

Days and Month	Grand Junction, Elevation 4,587			Fort Collins, Elevation 4,985			Garnett, Elevation, 7,576		
	90°	95°	100°	90°	95°	100°	90°	95°	100°
Average number days for May	1.09	0.0	0.00	0.00	0.00	0.0	0.00	0	0
Average number days for June	13.27	5.0	0.50	2.81	0.27	0.1	0.27	0	0
Average number days for July	23.72	13.0	3.36	8.27	2.00	0.0	0.09	0	0
Average number days for August	17.90	6.0	0.27	4.54	0.27	0.0	0.00	0	0
Average number days for September	3.00	0.0	0.00	0.10	0.00	0.0	0.00	0	0
Average number days for season	58.98	24.0	4.13	15.72	2.54	0.1	0.36	0	0

PSYLLID MIGRATIONS.—The almost complete disappearance of the insect from the Grand Valley during the summer brings up the question of the source of the early spring infestation. Sufficient numbers are not present when winter comes to account for it, and they have never been taken in hiberation in the state. The writer has been of the opinion that, in this section of the state at least, the spring infestation comes from some distant breeding ground through migrations. In a study of this phase of the problem a number of insect traps were operated in the Grand Junction area the springs of 1933, 1934 and 1935, in cooperation with the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture. During each spring psyllids were taken in sufficient numbers to account for the infestations that followed. In the opinion of those who examined the traps, at least a majority of the psyllids represented spring forms that could not have developed in the immediate vicinity. In addition they were often taken along with flights of the beet leafhopper, *Eutettix tenellus* (Bak.), that were known to be coming from southern Arizona. It is conceivable that with the coming of hot weather in the southern breeding areas, where the federal workers reported them as numerous on wild hosts, the psyllids took flight and were carried into the Grand Valley by the same air currents that brought in *E. tenellus*. This evidence is strengthened by the fact that at that time the psyllid largely disappeared from the southern breeding area. It is possible that other regions of Colorado may receive at least a part of their spring infestation from similar sources.

SUMMARY AND CONCLUSIONS.—Laboratory tests with the tomato psyllid, *Paratrioza cockerelli* (Sulc), indicate that the species thrives best at about 80 degrees with less retardation at temperatures below 80 degrees than above that point. Oviposition, hatching and survival are definitely reduced under 90 degrees constant temperature, while a temperature of 95 degrees for only two and three hours per day permit little, if any, in-

crease in numbers. One hundred degrees for one and two hours of the day are very definitely lethal to eggs and nymphs and practically stop all egg laying.

These results support field observations made over a period of more than 20 years. High temperatures cause the insect to disappear almost completely in the Grand Valley and Arkansas Valley, Colo., early each summer. In certain other regions, represented by Fort Collins, high temperatures appear to determine the summer population. In altitudes of 6,000 feet or more, the summer temperatures are seldom detrimental, in many cases the mean maximums are near the optimum for the species. Under these conditions increase is uninterrupted during the season, the seriousness of the infestation depending upon the degree of spring infestation. Some regions that experience lethal summer temperatures may have a definite building up of the population after mid-season, to the extent that tomatoes and late potatoes are seriously affected.

High temperatures make the adults very restless and may cause them to take flight and thus reach air currents that carry them great distances. Results of catches made in traps operated in the Grand Valley indicate that the spring infestation of this section comes, at least in part, from migrations.

There is a need for a more detailed study of the relation of temperatures to the psyllid problem in a number of the important tomato and potato growing portions of the affected area. There is also a very definite need for a comprehensive study of the insect over its entire range to determine more in detail the relationship of the southern breeding areas to the spring infestation of the northern and the high altitude regions.—8-10-38.

Mechanical and Other Factors Affecting Oil Spray Deposits*

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After several years of work on spray deposits with the building and setting up of apparatus, as well as the study of the various factors involved, the authors realized that certain mechanical factors must be considered. Due to the precision required in laboratory deposit tests and the fact that these tests are comparative it is necessary that the mechanical factors concerned with the procedure be carefully regulated. It has been found, as will be brought out, that variation and irregularity in the mechanical factors may decidedly affect the results obtained.

Although the various factors to be considered may apply to field spraying operations as well, the primary consideration here will be with reference to laboratory tests. These factors may also affect the deposits of sprays other than oil sprays.

Some of the mechanical factors affecting spray deposits have been mentioned at times by other authors. Smith (1932) mentioned and discussed certain of these factors. Borden & Hensill (1934) considered some of the mechanical factors and Dawsey, Cressman & Hiley (1937) also mentioned some of the factors.

It was felt that as complete a summary of these factors as is at present possible, including any experimental results, would be of interest.

MEASURING OF MATERIALS.—Exactness in measuring materials is important. Variations in amounts of materials may be one of the first things to affect comparability of results. This holds true for emulsifying and wetting agents as well as oils and powdered materials. It has been found that the use of good quality measuring and weighing apparatus which is well marked and easy to use is advantageous. The establishment and use of a definite order and procedure of measuring the materials for each type of spray is also of value. The use of a definite routine lessens the possibility of mistakes and the likelihood of indecision as to the next step.

MIXING OF MATERIALS.—The same principle of a definite order and procedure for mixing of materials holds true as it does for measuring. In fact, the wrong procedure of mixing materials may at times cause the loss of a tank of spray.

* Contribution from research laboratories of the California Spray Chemical Corporation.

Mixing of materials refers not only to the order of adding materials to the tank but also to the physical condition of the spray, depending on the period of time during which it is mixed through the pump.

The period of mixing through the pump, especially under pressure, has shown decided variation in the droplet size of the resulting emulsions. With the decrease in droplet size due to longer periods of mixing there has been found a corresponding tendency toward decrease in oil deposit with the decreasing droplet size.

Figures are given in table 1 showing the deposit of oil on beeswax-coated oil

Table 1.—Deposit and droplet size of oil on beeswax-coated bottles with various periods of mixing.

Minutes Mixed Through Pump under Pressure	Turbidity in Tank at Time of Spraying, Arbitrary Units	Milligrams of Oil Per Square Inch on Beeswax
2½	190	0.55
5	110	0.55
10	80	0.45
20	55	0.41
40	43	0.41
80	39	0.37

sample bottles with various periods of mixing. The turbidity of the emulsion in the tank at the time of spraying, being a function of droplet size, is given from readings made on an especially constructed turbidimeter using a 1 per cent dilution of the mixture in the tank. The emulsion referred to in the table was mixed in the tank and passed through the pump under pressure. Two per cent of a heavy medium oil was used, the emulsifier being one of a number of plant stock solutions.

THE SPRAY PUMP.—The main requirement as to the spray pump itself is that it be of sufficient size and durability of construction to do the necessary work. Good equipment will give better performance and run longer without repairs than the equipment which is light or inadequate. The pump should be capable of maintaining a constant pressure and delivery.

As to the effect of pressure variation on deposit some data have been obtained. Tests made with pressures varying from 225 to 600 pounds per square inch at the pump showed increases in deposit with increases in pressure on beeswax-coated bottles, table 2. The tests were made with a standard dormant oil emulsion. The distance from nozzle to bottles was 10 feet.

Table 2.—Pressure and deposit on beeswax-coated bottles.

Pressure at Pump	Milligrams of Oil Per Square Inch on Beeswax
225 pounds	1.09
280 pounds	1.33
415 pounds	1.35
500 pounds	1.36
600 pounds	1.38

PERIOD OF EXPOSUE TO SPRAY.—For definite comparative results to be obtained, the period of exposure of the test objects to the spray should be constant. Several different tests as to the effect of the time of exposure on deposit have all given the same results. The results of such tests on beeswax-coated bottles with a pressure of 250 pounds at a distance of 10 feet from the nozzle are given in table 3. Tests were made with a standard dormant oil emulsion at a concentration of 2 per cent.

Table 3.—Time of exposure to spray and deposit on beeswax-coated bottles.

Time of Exposure in Seconds	Milligrams of Oil Per Square Inch on Beeswax
3	0.53
6	0.55
9	0.55
12	0.61
18	0.69
24	0.74
30	0.67
45	0.71
60	0.80
90	0.88
120	0.86
150	0.82

CONSISTENT EXPOSURE OF TEST OBJECTS TO SPRAY.—In conducting comparative deposit tests it has been found necessary to rotate the object being sprayed or to move it in some manner in front of the spray since the nozzle is usually stationary. Various devices have been used and previously described (Borden & Hensill 1934, Dawsey *et al.* 1937 and

Tihenko & Hensill 1937). Most experimenters have used the rotation method, the optimum speed of rotation having been found to be 20 revolutions per minute.

Various devices have also been used to regulate the period of exposure to spray of the test object.

Apparatus may vary with different workers but the important point is that the mechanical condition and operation of any one apparatus must be consistently maintained and regulated in order that comparable results be obtained.

THE NOZZLE.—This is one of the most important parts of the spray apparatus where comparative tests are to be made and accurate results are desired. It has been found in experimental work by checking deposits with a standard emulsion that the slope or pitch of the nozzle with reference to the test objects must always be the same. With the type of nozzle used in our work this has been done by sighting through the nozzle to a fixed point some distance in front of it.

Table 4.—Distance from nozzle and deposit on test objects.

DISTANCE FROM NOZZLE IN FEET	MILLIGRAMS OF OIL PER SQUARE INCH ON BEESWAX
10	1.36
15	1.31
20	1.25
25	1.19
30	1.13

It has also been found that variation in the size of the orifice in the nozzle will affect results. To insure regularity the orifice diameter must be checked regularly and new discs installed whenever the orifice has widened. Small steel drills make very good instruments for determination of nozzle diameter.

Best results have been obtained with a nozzle throwing a solid cone stream of spray. This is similar to the stream of spray thrown by the long range adjustment of the average spray gun. The nozzle used in this work for laboratory apparatus is a *Vermorel* nozzle the disk being cone shaped with the cone out. The orifice is in the center of the tip of the extended cone.

The distance from the nozzle to the test object is also important and has been found to affect results. In laboratory tests a standard distance of 10 feet from the nozzle to the center of the apparatus rotating the test objects has been used. Some results of deposit tests at different distances from the nozzle are included in table 4. The tests were made with a standard dormant oil emulsion at a pressure of 500 pounds with five seconds exposure to the spray.

AIR CURRENTS AND TEMPERATURE.—The main effect of air currents on the deposit of a spray is from winds which may deflect the stream of spray away from the test object. To overcome this it has been found advantageous to inclose laboratory spraying equipment in a building or room so that any effects of wind are eliminated.

As to the effects of temperature on the deposit of sprays some evidence has been obtained indicating that ordinary ranges in temperature have no significant effects on spray deposits. An extensive series of deposit tests was conducted with a standard oil emulsion in which sprays varying between 8 degrees and 22 degrees C. were used under air conditions of similar temperatures. These temperature ranges were found to have no effects on the oil deposits nor were any differences found when the temperatures of sprays and air were not in accordance.

SURFACES USED FOR DEPOSIT TESTS.—Considerable work has been done by the authors and by other workers in making comparative deposit tests on sprays, using wax-covered oil sample bottles. Several workers have used beeswax as a standard surface. Paraffin on mica discs was used by Dawsey & Haas (1933) and plain glass as well as orange leaves were used by Smith (1932). Other investigators have used natural surfaces for deposit tests such as citrus leaves. The surface of apples has also been used.

The authors made a very extensive series of deposit tests on various artificial and natural surfaces. The conclusion was reached that beeswax, out of several tested, was the most satisfactory artificial surface. Evidence has also been obtained which indicates that natural surfaces are the best to use when they are obtainable in sufficient quantities and are of uniform condition.

Artificial surfaces are always available and can always be reproduced to an ex-

actness of specifications. Natural surfaces may tend to vary but where replication of samples can be obtained it seems logical that they should give the best comparative results.

It has been found in our work with a very few exceptions that more oil per square inch was deposited on the surfaces of orange leaves than on the surfaces of waxed bottles. Table 5 shows the deposits obtained in a series of tests on the same spray mixture on orange leaves, beeswax-coated bottles and bottles coated with *Mix-Wax* (a mixture of beeswax and carnauba wax). The determination of oil deposit on leaves was made by the method of Tihenko & Hensill (1937). Oil deposits on the waxed bottles were made by weighings. Sprays were applied under a pressure of 250 pounds at the pump at a distance of 10 feet from the nozzle. Time of exposure to the spray was 10 seconds. Oil concentration was $1\frac{2}{3}$ per cent. These tests were made over a period of six weeks. Similar results have been obtained by other workers including Smith (1932) and Dawsey and others (1937).

Surfaces used in making comparative laboratory deposit tests should be free from dust or dirt, moisture and other foreign material.

Table 5.—Oil deposit on orange leaves and waxed bottles.

TEST	MILLIGRAMS OF OIL PER SQUARE INCH OF SURFACE		
	Beeswax	*Mix-Wax*	Orange Leaves
1	0.37	0.15	0.49
2	0.36	0.15	0.51
3	0.32	0.16	—
4	—	—	0.50

DRYING OF TEST OBJECTS PRIOR TO DEPOSIT DETERMINATION.—Where comparative deposit tests are being made on bottles coated with waxes or other materials the deposit determinations, in our work, have been made by weighings. Waxed bottles were weighed before being sprayed, not less than 12 hours after being waxed. To obtain the weight of deposits the bottles were weighed approximately 24 hours after being sprayed. The drying time of 24 hours was determined experimentally by spraying sets of bottles with a standard emulsion and making weighings at intervals from the time of spraying up to 96 hours, table 6.

Table 6.—Oil deposit in relation to drying time.

HOURS DRIED	MILLIGRAMS DEPOSIT PER BOTTLE	
	Beeswax	*Mix-Wax*
0	202.0	287.0
2	33.6	19.1
4	15.3	13.7
6	14.6	12.5
8	14.5	12.6
12	12.0	10.0
16	12.0	10.0
20	12.7	10.6
24	11.4	10.6
28	11.1	11.1
32	11.4	11.4
40	12.0	10.4
48	10.2	10.8
56	10.2	9.2
72	9.8	9.3
96	8.9	8.2

As to the atmospheric conditions for drying of test objects, it has been found that ordinary laboratory room temperatures and humidities are satisfactory. A separate room or partially closed cabinet which can be kept free from dust has been found more advantageous than an open room where other types of work are being conducted.

SUMMARY.—A discussion of mechanical and some other factors affecting spray deposits have been given. Data as to the effects of some of these factors on deposits have also been presented.

The various mechanical factors associated with the application of sprays have been shown definitely to affect the amounts of insecticidal materials deposited.

It has been found that more oil per unit of area is deposited on natural surfaces than on artificial surfaces.

By keeping close checks on the apparatus and other factors concerned with spray application it is possible to obtain close results in different tests.—8-10-38.

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Pear Bud Injury and the Pear Leaf Blister Mite

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The destruction of pear buds during the winter months, the abundance of weakened buds at blossom time and russetted, imperfect fruit at harvest time have been observed for many years on trees which did not show blistering of the new foliage.

The cause of this damage was first recorded in California by Parker (1928a) although Tucker (1924), four years earlier, reported similar injury in South Africa. The nature of the injury and the habits of the mite involved were so entirely different from those of the blister mite that it was at first considered to be either a new species or a variety of the pear leaf blister mite, *Eriophyes pyri* Pgst. While the activities of the form producing the winter bud injury, the blossom injury and fruit russetting, with the absence of blistering, might indicate a new species, anatomical studies have so far revealed no structural differences which might separate the bud form from the blister form. Therefore, this mite is considered at present to be identical with the well-known pear leaf blister mite.

HOSTS.—This mite commonly infests apple and pear in both Europe and America, and as Borden (1932) reports, has been found attacking service berry, cotoneaster, white beam tree, European mountain oak and the wild service tree.

INJURY.—With severe fall infestations, the fruit and terminal buds may turn brown early in the winter, flare open and become so dry that they drop off when touched. More commonly the mites feed on the floral portions of the buds, and the more severely injured buds fail to open. Others open with one or two weak blossoms, which either fail to set or produce russetted or misshapen fruit. The result is that the crop in infested orchards may average less than 50 per cent no. 1 pears at harvest. All misshapen pears, however, cannot be attributed to the activities of this mite.

The results obtained from tagging 100 fruit spurs which showed partial bud injury gave a total of 44 spurs setting 62 fruit, of which 36 (58 per cent) were marketable.

Subsequent feeding on the new growth shows no apparent damage unless the mites are extremely abundant, and then there may be a stunting of the growth.

LIFE HISTORY.—The mites causing the bud injury begin to enter the terminal and leaf axil buds from the middle of June to August or as soon as the new growth begins to harden. In the Sierra foothill region this may be somewhat earlier. The mites remain inactive under the outer bud scales until September or October, when they begin to work their way toward the center of the bud.

Egg deposition within the buds begins in September and continues until the end of the growing period in June. As the eggs hatch and develop, the mites work into the floral portions of the buds. Table 1 gives the relation between the number of mites and eggs present during the winter months.

When the buds open in the spring the mites move out with the new growth, feeding on the fruit, in the leaf axils and especially at the growing tip until growth ceases. There are probably several generations a year, as all stages can be found from the end of September until June.

The habits of the bud form differ greatly from those of the blister form. A comparison is shown in table 2.

CONTROL.—The inability of a fall or cluster bud lime sulfur spray, the usual control for the pear leaf blister form, to prevent fruit or bud damage was early recognized by Borden (1932), Crane (1928) and Parker (1928a, b).

As the mites begin to enter the buds

Table 1.—Relative abundance of mites and eggs of pear leaf blister mite in infested buds during winter months.

		Mites		Eggs	
Orchard	Date	Per Cent Buds Infested	Average Per Infested Bud	Per Cent Buds Infested	Average Per Infested Bud
Wygersma	10/ 9/36	72	6.8	24	4.3
	11/17/36	80	23.7	72	20.3
	12/29/36	88	37.9	84	34.8
	2/25/37	88	31.0	80	52.6
Murphy	10/ 9/36	24	6.6	12	3.5
	11/17/36	20	12.4	12	11.7
	12/29/36	—	—	—	—
	2/25/37	40	53.0	36	99.5
Caldwell	10/ 9/36	40	3.3	12	3.3
	11/17/36	68	12.2	52	7.2
	12/29/36	76	20.0	76	11.2
	2/25/37	60	7.8	56	10.0

as early as June, and since it is impossible to kill them when established deep in the bud, late applications cannot prevent bud injury.

Borden (1932) demonstrated that the period of August and September is the most effective period for control, even though the foliage is still present on the trees. The success of the application of the spray consisting of 2 per cent summer oil and 5 per cent lime sulfur depends upon its contacting the mites before they have gone too deep under the bud scales. This means that the spray must be applied as soon as the crop has been harvested. In the Sierra foothill region the crop often remains on the trees until in September, and growers are unable to make early applications. Thus applications are delayed until October or later and fail to effect a control. Table 3 shows the effect of the time of application of the fall spray combination in reducing the amount of winter bud injury. It can be readily seen that applications made in early September (Murphy orchard) gave good control, while late applications (Miller and Clark orchards) did not prevent severe bud injury and a reduced number of blossoms.

Experiments conducted in this region showed that the addition of 5 pounds of wettable sulfur to the calyx and first codling moth cover sprays provides an adequate check on the development of this mite. The results of these experiments are given in table 4.

Observations made in orchards where nicotine sulfate has been added to the codling moth sprays as a control for pear thrips indicate a considerable reduction in the number of bud mites on the new growth.

SUMMARY.—The bud form of the pear leaf blister mite causes considerable losses in the pear growing sections of California through the winter destruction of fruit buds. The habits of this form are very different from the blister form, although no structural differences have been found, and for this reason they are considered to be the same species. In some sections, especially in the Sierra foothills, harvest

Table 2.—Comparison of habits of bud form and blister form of the pear leaf blister mite.

Seasonal Activities	Bud Form	Blister Form
Winter months	Actively feeding and multiplying in buds	Hibernating under bud scales
When blossoms appear	Feeding on developing fruit, causing it to become russetted and misshapen	Attacking new foliage and fruit, producing blisters
Spring and early summer	Feeding and multiplying on growing tips	Causing blisters on new growth
Late summer	Inactive in axils of leaves and in terminal buds	Continuing to cause blisters on new foliage
Early fall	Becoming active in August and September; working deeper under bud scales	Often remaining in blisters until leaves drop; migrating to buds September–November
Oviposition	September to June	March to October

Table 3.—Effect of time of application of fall lime sulfur and oil spray in the control of the bud form of the pear leaf blister mite (Placerville area).

Orchard	Treatment	Date Applied	Date Checked	Per Cent Buds Infested	Average Number Mites Per Infested Bud	Degree of Blossom Injury at Full Bloom				
						Number of Fruit Spurs	Per Cent Buds Dead	Per Cent Buds Without Blossoms	Per Cent Buds With 1–4 Blossoms	Per Cent Buds With More Than 4 Blossoms
Miller	None	—	2/23/38	100	226.7	876	7.4	5.2	50.8	36.6
	5% lime sulfur 2% light medium summer oil	10/10/37	2/23/38	80	37.4	897	4.1	10.2	45.4	40.3
	5% lime sulfur 5% winter *Kleen Up*	12/26/37	2/23/38	100	202.8	946	9.8	7.1	57.6	25.5
	5% lime sulfur 2% light medium summer oil	10/10/37	2/23/38	60	24.2	852	5.7	8.5	55.1	30.7
	5% lime sulfur 5% winter *Kleen Up*	12/26/37	2/23/38							
Murphy	5% lime sulfur 2% summer oil emulsion	9/10/37	2/23/38	20	5.0	556	2.7	16.9	18.7	61.7
	2% summer oil emulsion	9/27 to 10/ 5/37	2/23/38	68	36.4	601	2.8	21.2	22.0	54.0
Clark	5% lime sulfur 2% summer oil emulsion	Sept.	2/23/38	—	—	530	2.1	5.7	34.7	57.5
	2% summer oil emulsion	Dec.	2/23/38	—	—	509	7.6	14.1	54.8	23.5

Table 4.—Effect of adding wettable sulfur to codling moth sprays to control the pear bud mite.

Treatment and Date Applied	Date Examined	Average Number of Mites				Average Number of Mites in Terminal Buds 10/14/37
		Per Fruit Spur	On Fruit	In Leaf Axils	On Terminals	
None	6/2/37	244.0	24.0	64.6	155.4	52.0
5 lbs. wettable sulfur in cover spray 5/17/37	6/2/37	73.4	0.7	19.0	53.7	13.0
5 lbs. wettable sulfur in calyx spray 4/24/37 and in cover spray 5/17/37	6/2/37	5.1	0.0	0.7	4.4	0.8

is so delayed that control measures cannot be applied before many of the mites have worked deep into the buds. In these areas the addition of 5 pounds of wettable sulfur to the early codling moth sprays was found to provide an adequate check on the activities of the bud form of the pear leaf blister mite.—8-10-38.

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The Six-Spotted Thrips, *Scolothrips sexmaculatus* (Perg.)

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Among the oldest species of thrips known from North America is the six-spotted thrips, *Scolothrips sexmaculatus* (Perg.). As early as 1882 Pergande recognized this thrips as predacious on red spiders. Quayle (1912) reported some of the first biological observations and illustrated the adult. Numerous entomologists since have called attention to its predacious habits, and its known distribution and host list have grown slowly. Its life history, however, has remained unknown.

ECONOMIC IMPORTANCE.—Like many predacious insects, the real value of the six-spotted thrips is impossible to evaluate accurately. It is rarely found in what might be called large numbers. Among infestations of red spiders on grapes, cotton, beans and walnuts, many of these thrips are to be seen during July, August and September. It is sometimes thought that spider infestations on these crops are actually controlled or noticeably reduced by this species of thrips. This may be possible, but it is quite unlikely since other factors contribute to the disappearance of red spiders in the late summer. The two principal factors are the activity of the predacious mite, *Seius pomi* Parr., and the sudden normal disappearance of red spiders at the peak of their infestation, many going into hibernation. The predacious thrips builds up very slowly and is often present only in small numbers, or absent altogether when the infestation is at its worst. Also, the rate of reproduction of the spiders is so great in proportion to that of *Scolothrips sexmaculatus* that there is little hope of the thrips becoming of any importance if artificially increased and liberated.

BIOLOGY.—The entire life cycle of the six-spotted thrips is passed on the host plants. The eggs are inserted in the more tender tissues of the leaves and shoots

as are those of most plant-feeding thrips of the suborder Terebrantia. Normal reproduction appears to be bisexual, although it was not ascertained whether or not parthenogenicity occurs. Both sexes have been collected and reared in the proportion of two females to one male. Very few eggs are laid; individual females under observation gave rise to only four or five larvae each. Mounted specimens exhibit as many as six mature eggs in the abdominal cavity. The length of the egg stage has been very difficult to ascertain; resting under the more dense webs on the leaves and on the under side of the leaves in the axils of the larger veins. Both the larvae and adults feed on the adult red spiders and mites as well as on the spider eggs. If crowded, the adults and larvae of *Scolothrips sexmaculatus* fight among themselves and are definitely cannibalistic under these conditions. Pupae and larvae ward off attacking individuals by flicking the abdomen rapidly from side to side. Weak or injured individuals are quickly attacked and killed. Other species

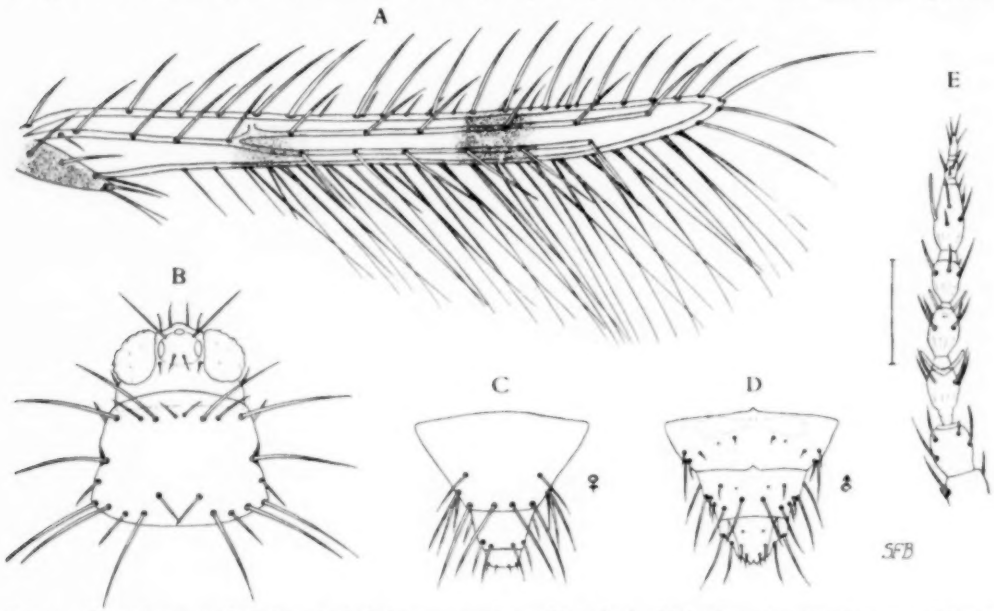

FIG. 1.—The six-spotted thrips, *Scolothrips sexmaculatus* (Perg.). A, Right forewing. B, Dorsum of head and prothroax. C, Dorsum of tip of abdomen of female. D, Dorsum of tip of abdomen of male. E, Right antenna. (Line of measurement at left of antenna = 0.1 millimeter.)

it is between 6 and 10 days and possibly shorter under optimum conditions. The larval stage in warm weather when mites are plentiful is often as short as five days; in the cooler weather of the fall, as long as three weeks. The prepupal stage lasts one day and the pupal stage five days (one case three days only). The adults live from two to three weeks. On plant food alone the adults can survive only three days. The larvae molt once when about half grown and again when passing to prepupal stage. One additional molt occurs between the prepupal and pupal stages.

The larvae, pupae and adults are found together on the leaves of the hosts among the spiders. Pupae are commonly seen of thrips are not attacked. The mites and eggs are encountered by chance as the thrips run about over the infested leaves. No system of hunting is employed by the thrips and they cover their tracks many times seeking food.

One-half to one minute is sufficient to suck up the contents of a red spider egg. From 5 to 20 minutes are consumed in feeding on a spider. The victim usually puts up a fight but is held down by the thrips with its front legs and rolled over before being pierced. One adult thrips has been observed in one-half hour killing three brown almond mites and feeding on six eggs. However, rather long intervals of resting are evidenced between periods of feeding; thus it cannot be said that

Scolothrips sexmaculatus is exactly voracious—a desirable characteristic of the better predators.

During the past four winters all attempts to determine the stage and place of overwintering have failed. In October the field population of *Scolothrips sexmaculatus* drops rapidly after reaching a seasonal peak the previous month. (The largest numbers ever observed by the writer were 50 larvae, pupae and adults combined on a single walnut leaf infested with the two-spotted mite.) Larvae and pupae are found up to the first of October, and adults are rarely found after the middle of October. Gravid females have been taken as late as October 14 at Davis. Quayle, however, wrote that this thrips was seen most abundantly in the winter and early spring (in southern California) feeding on the citrus red spider. After annual crops are harvested and deciduous trees have shed their leaves many painstaking searches have failed to reveal any stage of this thrips. Neither has it been found in greenhouses in the winter. Adults confined in cages outdoors and in the laboratory in the fall have died. No forms have been found among hibernating red spiders under the bark of grape vines. In northern California no larvae or adults have been observed earlier than April 26. (One female taken at this time had two eggs in the body cavity.) Reasoning from the above facts and what is known about thrips in general, it would seem that the winter is survived by a very few adults only. The actual place of hibernation will perhaps be found by chance.

DISTRIBUTION.—This insect is recorded from Africa, Australia, the Hawaiian Islands, India and South America, in addition to the United States. The following states at present may be listed in its distribution in this country: California, Connecticut, Florida, Illinois, Iowa, Maryland, New Jersey, New York, Missouri, Oregon, North Carolina, South Carolina, Nebraska and Wisconsin. More specifically, in California, this thrips has been collected by the writer from Chula Vista (San Diego County) northward through the San Joaquin and Sacramento valleys to Meridian (Sutter County). It is not common along the coast; only one record is at hand (from Berkeley) in northern California. As it is chiefly predacious on mites and red spiders this is perhaps to be expected; spider infestations are much more common in the warmer, less humid portions of the state. Also, the six-spotted thrips is much more easily collected from crops such as cotton, beans, walnuts, citrus, hops, almonds, prunes and grapes, all of which are frequently infested with various species of red spiders. However, occasional individuals are found in greenhouses, on ornamentals and on miscellaneous plants exhibiting red spider injury. The wide range in climate which this thrips can withstand is evidenced by its presence in North America from Florida to Nebraska, and California to New York. Without a doubt this insect is native and has a much wider distribution in North America than indicated by the above records.

HOSTS.—Technically the plants from which *Scolothrips sexmaculatus* has been collected are not its true hosts, naturally, since it is predacious. These plants, however, which are attacked by various mites include almond, apple, avocado, Balm of Gilead, bean, blackberry, *Buxus*, cedar, *Cestrum*, *Cholam*, citrus, corn, cottonwood, *Eleagnus*, elm, grape, hollyhock, hop, *Ipomea*, juniper, Oriental plane, orange, peach, pear, plum, pomegranate, prune, *Psidium* and walnut. The species of mites on which this thrips is known by the writer to feed are the common red spider, *Tetranychus telarius* (L.); the Pacific mite, *T. pacificus* McG.; the clover mite, *Bryobia praetiosa* Koch; the citrus red mite, *Paratetranychus citri* McG.; the European red mite, *Paratetranychus pilosus* (G. & F.); the cholam mite, *P. indicus* Hirst.; the avocado red mite, *P. yothersi* McG.; the plane tree mite, *P. ilicis* McG.; and the silver or citrus rust mite, *Phyllocoptes oleivorus* Ashm.

TAXONOMIC POSITION.—The six-spotted thrips is a member of the large family Thripidae, which includes the majority of the species of economic importance. The genus *Scolothrips* is very distinct and has for many years been represented only by *sexmaculatus*. As a result of being distinct, due chiefly to the spots on the wings and the long bristles, it has been easily identified and has few synonyms.* There are

* Synonymy of *Scolothrips sexmaculatus* (Perg.)
Thrips 6-*maculata* Pergande. 1892. Trans. Acad. Sci. St. Louis 5:539. (Manuscript name given as footnote in a paper by J. C. Duffy.)
Thrips pallida Beach, 1895 (1896). Proc. Iowa Acad. Sci. 3:226–227.
Scolothrips 6-*maculatus*, Hinds, 1902. Proc. U. S. Natl. Mus. 26:157–158.

two other species in this genus, *longicornis* Pries. (1926) and *acariphagus* Yakh. (1934), as well as the doubtful species *uzeli* Schille described in 1910.

DESCRIPTION OF STAGES.—The adult female averages about 0.8 millimeters in length. The color varies from clear white to orange yellow. With the exception of the first two segments, which are pale yellow, the antennae are dusky gray. The eyes (fig. 1, B) are large, dark red to purple; the three ocelli are prominently located on the vertex. Forked sense cones are present on the third and fourth antennal segments (fig. 1, E) and a long, slender, simple sense cone on the sixth segment. Aside from two long spines arising anterior to the lateral ocelli, several pairs of spines on the dorsum of the prothorax (fig. 1, B) and generally strong spines on the forewings, the body is not heavily spined. Each forewing (fig. 1, A) has three brown spots; the basal one being the scale at the base of the wing, the second located about one-third the length of the wing from its base, and the third about half way between the central spot and the tip. Both anterior and posterior longitudinal veins of forewing have four to seven spines. One spine at point of union of the two veins may be on either vein. Two to four spines on united or basal portion of veins. Hind wing is clear, with one longitudinal vein. The female is larger than the male and more robust. The sexes may be differentiated by the terminal abdominal segments (fig. 1, C and D).

Mature larva translucent white to orange yellow and about the same size as the adult. Antennae six-segmented without sense cones. Spines on head and prothorax similar to adult. Eyes dark red to purple. No ocelli. Abdominal segments covered with many long spines. Tip of abdomen blunt without long terminal spines.

Pupa more robust than larva. Color pale yellow. Eyes red. Spines on head, thorax, abdomen and wing pads prominent. Antennae folded back on dorsum of head. Four very strong spines or claws on the dorsum of the penultimate abdominal segment.—8-10-38.

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Trapping Elaterid Beetles as a Control Measure Against Wireworms*

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Investigators of wireworms early observed that elaterid beetles or click beetles, the adults of wireworms, have the habit of gathering under beet tops, slices of potato, piles of straw or other debris lying on the soil surface in open fields. The possible advantage that might be taken of this habit in trapping and collecting these beetles was called to the writers' attention by E. W. Gerry of Ventura, Calif., who in 1930 put out small piles of malva at the rate of one trap pile to the acre in a 12-acre bean field and collected nearly 7,000 beetles underneath these piles. In 1931 he collected over 9,000 beetles from the same field, although the trap piles were not put out until several weeks after the beetles had begun flying.

FIG. 1.—Pile of malva on the ground being used as a wireworm beetle trap.

These results led the writers to investigate the utilization of the trapping method as a possible aid to wireworm control. In these investigations two objectives were kept in mind: (1) to attract the beetles under the traps and then collect, poison or kill them in some manner so as to prevent oviposition and (2) to allow the beetles to remain under the traps for egg laying so that the eggs would be concentrated in small areas where they could be destroyed readily by treating the soil prior to the time of hatching.

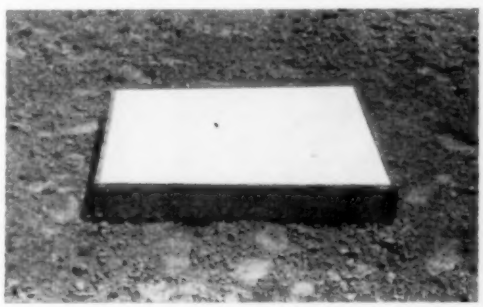

FIG. 2.—Cage for capturing beetles as they emerged from the soil.

In 1932, 53 traps were placed in Mr. Gerry's field and from these traps 12,686 beetles were collected. The planting of young lemon trees in this field apparently interfered with the efficiency of the traps as the trees became larger, since, in 1933, 10,190 beetles were trapped and in 1934 only 4,635. It was then decided to abandon the work in this field and concentrate on infested fields that would continue as open fields.

Experiments in two fields in Orange County and in one in Los Angeles County had been started in 1932. The latter and one of the former had to be abandoned because the owners planted other crops during the emergence period. An experiment in an additional field was started in Orange County in 1935. This paper discusses the results of six years of trapping in one field and two years in another.

* The information given in this paper refers to the sugar-beet wireworm, *Limonius californicus* (Mann.). Although data regarding them are not included, lesser numbers of the following species were also collected: *Melanotus longulus* (LeC.), *Aeolus livens* (LeC.), *Cardiophorus tenebrosus* LeC., *Anchastus cinereipennis* (Esch.), and *Melanactes densus* LeC.

NATURE OF TRAP.—Most of the trap piles used in this investigation were composed of an armful of the common weed malva, *Malva parviflora* L., sometimes known as mallow or cheeseweed. These piles, fig. 1, ranged from $2\frac{1}{2}$ to 3 feet in diameter. A thick-stemmed mustard used for orchard cover crops proved equally satisfactory, but fine-stemmed plants such as alfalfa were much inferior to malva. Sacks or boards were entirely unsatisfactory as traps. Experience demonstrated that it was necessary to have, for use as a trap, a fairly loose pile of thick-stemmed plants into which the beetles could penetrate easily, but which would be dense enough so that no part of the soil underneath would be exposed, since the beetles did not remain underneath the piles unless the soil surface was moist. The surface of the soil under each pile was scooped out slightly. Owing to drying out and loss of foliage, fresh malva had to be added once or twice during the trapping period.

NUMBER OF BEETLES CAUGHT IN TRAPS.—At periods of one to three days the traps were examined, and the beetles attracted to them were collected. All such beetles were either used for experimental purposes or destroyed. The results of trapping during the years 1932–37 are shown in table 1. Starting in 1932 with 1,121 beetles per acre from 10 traps in the Murdy field, the catch dropped in 1933 and 1934 to 666 and 708 per acre, respectively, from 22 traps. In 1935 it increased to over 2,100 per acre, but dropped to 1,188 in 1936 and to 854 in 1937. The beetles were extremely numerous over the entire area in 1935. Beetles were taken in the traps early and were found in them until late in the season, probably owing to several heavy rains during the period. In previous seasons there had been practically no rainfall during the trapping period. Undoubtedly both the large number of beetles present over the entire area and the long, cool trapping period accounted for the large catch in 1935. In Ward's field the number caught per acre was the largest during the entire investigation.

Table 1.—Results of trapping wireworm beetles, *Limonius californicus*, under piles of malva in Orange County, Calif., 1932–37.

FIELD	YEAR	NUMBER		TAPPING PERIOD			NUMBER OF BEETLES CAUGHT		
		Acres	Traps	Beginning	Peak	End	Total	Per Trap	Per Acre
Murdy	1932	5	10	Mar. 6	Mar. 31	Apr. 21	5,603	550	1,121
	1933	5	22	Mar. 3	Mar. 20	Apr. 12	3,333	152	666
	1934	5	22	Mar. 4	Mar. 19	Apr. 10	3,541	161	708
	1935	5	22	Feb. 28	Mar. 31	Apr. 22	10,601	482	2,120
	1936	5	22	Feb. 24	Mar. 16	Apr. 23	5,943	270	1,188
	1937	5	60	Mar. 4	Apr. 10	Apr. 22	4,272	71	854
Ward	1935	10	49	Feb. 22	Mar. 29	Apr. 24	*13,301	633	†3,102
	1936	10	49	Feb. 24	Mar. 18	Apr. 22	* 3,393	161	† 792

* Count from 21 traps only.
† Based on the estimated catch from all 49 traps.

Owing to the shortage of rainfall in 1936 the fields, which had been dry-plowed in the fall, were very cloddy. They were irrigated and harrowed during the trapping period, which was slightly longer than in 1935. The number caught in Murdy's field was about one-half and in Ward's about one-fourth of the catch in 1935.

Traps were put out only in Murdy's field in 1937, alfalfa having been planted in Ward's field. Forty traps were placed 50 feet apart and 20 traps 75 feet apart. Conditions were even more unfavorable for trapping than in 1936. There were several heavy rains, after which the soil surface dried and cracked. Grass and weeds grew in part of the trapped area and attracted many beetles which might have gone to the traps. Very small numbers of beetles were taken in the daily collections over most of the period, and the total number collected per acre for the season was only 854.

EFFECT OF TRAPPING ON WIREWORM POPULATIONS.—Previous to 1936 the only check on the effect of trapping the

Table 2.—Wireworm populations in Murdy's trapped field as compared with those in several nearby untrapped fields.

Year	Beetles Caught in Malva Traps	Wireworm Population Per 10 Feet of Wheat Row Planted in March	Murdy's Trapped Field	Wireworm Population Per 10 Feet of Bean Row Planted in April Adjoining Untrapped Fields				
				1 Promen	2 Woodington	3 Lewis	4 Beam	5 Murdy No. 2
1932	5,603	—	—	—	—	—	—	—
1933	3,333	30.8	—	—	—	—	—	—
1934	3,541	10.3	*3.8	7.7	12.3	14	—	†2.4
1935	10,601	10.5	8.1	—	8.5	‡	3.3	14.7
1936	5,943	23.4	8.4	—	7.5	—	—	6.9
1937	4,272	30.0	—	—	—	—	—	—

* This field was pre-baited in 1934 and counts were made only in the planted crop row. From comparative counts made this year the population counts in planted rows of pre-baited fields are reduced about one-half. Hence for comparative purposes the count of 3.8 wireworms should be at least doubled.
† The soil was very dry when this count was made and the wireworm population in the rows was accordingly low.
‡ Beets planted.

adults was by an attempt to compare the wireworm populations in trapped and nearby untrapped fields. This was done in Murdy's field during the years 1934 to 1936, inclusive, by planting rows of wheat in March and, 10 days later, counting the numbers of wireworms attracted to 10-foot strips of row. A further check was made by digging up similar strips of lima beans, both in trapped and in untrapped fields, 10 days after the crop had been planted. A few 1-square-foot counts were also made.

Because of lack of time and assistance, it was impossible to obtain sufficient data for a satisfactory comparison of results. Such information as was obtained is shown in table 2. As determined by wheat-row counts, the wireworm population in Murdy's field decreased in 1934, remained stationary in 1935 and increased in 1936, while in 1937 it was practically the same as in 1933. In the bean rows in Murdy's trapped field the number of wireworms was about the same in 1934, 1935 and 1936, while in Woodington's untrapped field the 1935 count was 30 per cent less than in 1934 and, in 1936, 10 per cent less than in 1935. Murdy's untrapped field no. 2 shows a wide variation in wireworm population during the three years that counts were made. Data from the remaining fields were insufficient for interpretation.

BEETLE POPULATION OF INFESTED FIELDS.—Since the available data on wireworm populations in trapped fields as compared with untrapped fields were insufficient to furnish definite conclusions regarding the value of trapping beetles, it was decided to find out the actual beetle populations of the fields under observation and compare such populations with the number of beetles caught in the traps. To obtain this information a series of cages was put out during 1936 to capture the beetles as they emerged from the soil. These cages, fig. 2, were 3 feet square by 4 inches high, covered with cheesecloth. They were constructed tightly,

Table 3.—Comparative populations of beetles of *Limonius californicus* captured in emergence cages and under malva traps in Ward's field during 1936, and in adjacent fields where trap piles had not been used during previous years.

Field	Number of Cages	Number of Square Feet Covered by Cages	Number of Beetles Emerging in Cages		Average Number Per Square Foot Emerging in Cages		Calculated Number Per Acre Based Upon Cage Emergence		Number of Beetles Caught in Malva Traps Per Acre*	
			Total	Females	Total	Females	Total	Females	Total	Females
Ward	20	180	83	35	0.461	0.194	20,081	8,450	792	507
No. 6	16	144	48	14	0.333	0.097	14,505	4,225	—	—
No. 7	12	108	13	3	0.120	0.027	5,227	1,176	—	—

Table 4.—Comparative populations of beetles of *Limonius californicus* captured in emergence cages and under malva traps in Murdy's field during 1936 and 1937, and in nearby fields where trap piles had not been used during previous years.

Field	Year	Number of Cages	Number of Square Feet Covered by Cages	Number of Beetles Emerging in Cages		Average Number Per Square Foot Emerging in Cages		Calculated Number Per Acre Based Upon Cage Emergence		Number of Beetles in Malva Traps Per Acre	
				Total	Females	Total	Females	Total	Females	Total	Females
Murdy	1936	20	180	112	59	0.622	0.327	27,094	14,244	1,188	891
Murdy	1937	17	153	58	31	0.380	0.203	16,553	8,843	854	670
No. 2	1936	18	162	55	22	0.339	0.136	14,767	5,881	—	—
No. 2	1937	10	90	28	23	0.310	0.255	13,504	11,108	—	—
No. 4	1936	8	72	32	14	0.444	0.194	19,341	8,451	—	—
No. 4	1937	10	90	15	11	0.166	0.122	7,231	5,314	—	—

with a 3-inch strip of galvanized iron around the inside lower edge, which extended down into the soil so that only those beetles emerging from that part of the field covered by the cage were captured. This gave an adequate basis for an estimate of the beetle population of the fields where these cages were used. In all, 107 of these cages were put out in Murdy's and Ward's and in five nearby fields prior to the emergence of the beetles. The cages were examined weekly and the beetles removed. Ward's field had been malva-trapped for one year and Murdy's for four years previously. Fields 6 and 7 were adjacent to Ward's, while 2 (Woodington) and 4 (Beam) were near Murdy's. (See table 2.) The results are shown in tables 3 and 4.

NUMBER OF BEETLES EMERGING IN EXCESS OF THOSE TRAPPED.—The striking thing brought out in the use of emergence cages is that the number of beetles which emerged far exceeded the number taken under the malva traps. Considering females alone, 507 per acre were trapped at Ward's with malva, while 8,450 emerged from the soil. At Murdy's, in 1936, 891 females per acre were attracted to the malva traps, but 14,244 emerged. The figures for 1937 are proportionate.

These figures indicate that the malva traps captured far fewer beetles per acre than emerged. They also indicate, in Murdy's field, that previous trapping for four years did not reduce the wireworm population, at least that proportion which emerged as beetles in 1936 and 1937. This may be due to the failure to attract all the beetles to the traps and, moreover, to the fact that some of the eggs may have been laid under the traps by the beetles before the beetles were collected. This latter supposition is borne out by the fact that the average egg production of malva-trapped females is far less than that of reared specimens, as is shown in table 5.

INSUFFICIENT NUMBER OF MALVA TRAPS.—Based on the figures from emergence cages as compared with those from malva traps, the results of 1936 showed the malva traps to be of questionable value. It appeared either that the traps were not sufficiently attractive or that they were too few in number to attract enough beetles to control the wireworms. Some evidence can be furnished on both premises. Of the 22 traps in Murdy's

Table 5.—Egg production of trapped and reared female beetles of *Limonius californicus*, Alhambra, Calif., 1931–37.

Year	Number of Eggs From Beetles								
	Trapped Under Malva			Reared in Salve Tins			Reared in Tile Cages		
	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.
1931	—	—	—	294	89	191.2	233	123	177
1932	—	—	114.0	372	122	262.7	408	65	221
1933	307	3	126.4	543	397	468.0	359	213	273
1934	327	6	83.2	704	382	517.0	279	51	142
1936	225	0	68.9	—	—	—	—	—	—
1937	172	8	60.0	—	—	—	216	16	115

field, 6 were 150 feet apart and 16 were 100 feet apart. An examination of the figures in table 6 shows that, with the exception of 1935, more beetles per trap were caught when the traps were 150 feet apart than when they were closer together, but that this ratio is far less

Table 6.—Comparison of number of beetles of *Limonius californicus* caught per trap and per acre when traps were 100 and 150 feet apart, in Murdy's field during the seasons 1933–36.

Season	Number Caught Per Trap When Traps Were		Number Caught Per Acre When Traps Were	
	100 Feet Apart	150 Feet Apart	100 Feet Apart	150 Feet Apart
1933	130	192	637	480
1934	155	186	759	465
1935	493	451	2,416	1,128
1936	243	294	1,191	735
Average	*255*	*281*	*1,251*	*702*

than the difference between the number of traps per acre. In a 10-acre field there would be 49 traps if these were placed 100 feet apart, but only 25 if they were placed 150 feet apart (allowing a 30-foot strip around the field outside the traps). Because of the greater number of traps, the catch per acre was greater with the traps 100 feet apart, even in those years when these traps attracted fewer beetles per trap than those 150 feet apart. It seemed logical that if more traps per acre were put out at some such distance apart as 50 or 75 feet, the catch per acre would be materially increased. In Ward's 10 acres, for example, at 75 feet apart there would be 81 traps and at 50 feet 169 traps.

Accordingly, in 1937, the traps in Murdy's field were placed 50 and 75 feet apart. Conditions for trapping were very unfavorable, and the total catch was the lowest since 1934. When the traps were placed 50 feet apart the average catch per trap was 76 beetles, and when they were 75 feet apart it was 60 beetles. In the latter case, however, the traps were in that portion of the field containing most of the grass and weeds. Under the conditions of the experiment the traps that were 50 and 75 feet apart did not attract any greater proportion of the emerging beetles than did those 100 feet apart.

INSUFFICIENT ATTRACTIVENESS OF THE TRAPS.—In an endeavor to obtain evidence on the attractiveness of the malva traps, 300 female beetles which had been collected previously in malva traps were marked with red paint and liberated in the center of Ward's 10-acre field containing 49 traps. Later 203 white-marked females were liberated. Recoveries by days are recorded in table 7.

This shows recoveries of only 3 and 28 per cent of the liberated females. The traps were not attractive, they were too few, or else the beetles flew beyond the limits of the trapped field. Cracks in the soil, as it dried out following a heavy rain, may have attracted some of the females as favorable places for oviposition. In 1935, 16 traps were put out at random around a central point at distances ranging from 50 to 150 feet from the point. On March 13, a cool, cloudy day, 290 females and 164 males which had been collected the previous day were marked with paint and liberated in the center of the area. Collections were made from March 15 to April 15 and during this time 31 males, or 19 per cent, and 77 females, or 27 per cent, were recovered. During this time 9,560 unmarked beetles were collected also.

Most of the marked beetles recovered were taken in the four traps within a 50-foot radius of the point of liberation. The largest number recovered, however, was 26, while the number liberated averaged slightly more than 28 for each of the 16 traps.

In one experiment beetles were liberated on a warm, sunny day. They immediately rose up and flew some distance

Table 7.—Recovery of marked female beetles of *Limonius californicus* in malva traps, Ward's field, Talbert, Calif., 1936.

Color	Number Liberated	Date	Number Recovered										Total Number Recovered
			March				April						
			20	23	24	30	1	6	8	10	13	23	
Red	300	Mar. 18	5	16	4	9	3	1	0	0	0	0	38
White	203	Mar. 23	—	—	8	16	11	10	3	5	2	2	57

Table 8.—Number and percentage of male and female beetles of *Limonius californicus* remaining under malva traps over a 20-day period, Talbert, Calif., 1935.

Date of Examination 1935	Days Beetles Remained Under Trap	Males Remaining in		Total Males	Per Cent Males Remaining	Females Remaining in		Total Females	Per Cent Females Remaining
		Trap 1	Trap 2			Trap 1	Trap 2		
Mar. 19	2	21	24	45	90	20	21	41	82
Mar. 21	4	21	20	41	82	19	20	39	78
Mar. 23	6	16	14	30	60	19	21	40	80
Mar. 25	8	14	14	28	56	19	21	40	80
Mar. 27	10	9	8	17	34	15	15	30	60
Mar. 29	12	7	8	15	30	17	11	28	56
Mar. 31	14	9	7	16	32	16	12	28	56
Apr. 2	16	6	6	12	24	12	9	21	42
Apr. 4	18	6	3	9	18	9	5	14	28
Apr. 6	20	3	2	5	10	2	5	7	14

out of sight. It is likely that collecting and painting the beetles disturbed them somewhat, so there was a tendency for them to fly away some distance. But the experiment indicates that the traps failed to attract a large majority of the beetles.

DURATION OF PERIOD BEETLES REMAIN UNDER TRAPS.—In an endeavor to find out if the beetles remained under the traps any length of time, 25 each of marked males and females were placed under two traps and examined on alternate days. As is shown in table 8, the males were more unsettled than the females, as less than half remained under the trap at the end of the tenth day, while 60 per cent of the females were still present. The number gradually decreased until 10 per cent of the males and 14 per cent of the females were still there on the twentieth day. Other observations showed that beetles would not remain under the traps unless these were dense enough to give good protection and unless the soil underneath them remained moist.

SEX RATIO OF THE BEETLES.—Sex ratios of the beetles have been observed for several years. Early in the period during which the beetles emerge from the soil the proportion of females is low. It shortly begins to increase, soon equals and then exceeds the proportion of males. Toward the end of the emergence period the percentage of females is very high. These ratios have held true in all years that this study has been going on, both in beetles from malva traps and in those from emergence cages at the laboratory in which wireworms were reared to maturity.

As shown in table 9, the average percentage of females among reared specimens ranged from 44 to 53 in different years. The percentage of females taken in the malva traps is much higher, showing that the latter were more attractive to females than to males.

Table 3 shows that the number of females caught in the emergence traps is less than half the total catch in each field, the average percentage being 36. Table 4 shows that in two of the fields in 1936 the percentage of females caught was less than half, while in the third it was slightly

Table 9.—Comparison of percentage of female beetles of *Limonius californicus* in daily catches from malva traps with that of reared specimens.

Year	Percentage of Females Among Beetles							
	Caught Under Murdy's Malva Traps			Caught Under Ward's Malva Traps			Reared in Salve Cans, Ave.	Reared in Tile Cages, Ave.
	Max.	Min.	Ave.	Max.	Min.	Ave.		
1932	81	36	64	—	—	—	—	—
1933	95	48	76	—	—	—	45	51
1934	93	67	81	—	—	—	45	53
1935	99	35	82	95	45	80	44	51
1936	100	51	75	100	22	64	—	—
1937	98	25	78	—	—	—	—	—

more than half. The average for the three fields is 48 per cent females. But in 1937 the number of females captured exceeded that of the males in all three fields, the average percentage being 64. Other observations indicate that the percentages of males and females may vary in different fields and in different localities. In the several years that the malva traps were operated in Ventura County the percentage of females was consistently less there than in Orange County. However, the percentage of females in the emergence cages is less in both years than that caught in the malva traps, indicating that the malva traps are more attractive to females than to males.

SUMMARY.—The habit of elaterid beetles of gathering under debris was used in an attempt to trap them as a control measure for wireworms. The trap was a pile of malva, thick-stemmed mustard or other coarse plants. It lost its attractiveness if it, or the soil underneath, became dry. Such traps attracted from 666 to 3,102 beetles per acre. During the six years of trapping in one field no apparent reduction in wireworm population was observed. The use of adult emergence cages during two years showed that the number of beetles emerging in the fields where the observations were performed far exceeded the number attracted to the malva traps.

The traps proved more attractive to the female beetles than to the males, and the females remained under the traps longer than did the males. Traps placed 150 feet apart attracted more beetles than did those placed 100 feet apart, but owing to the fact that there were more traps the number of beetles caught per acre was greater with the traps 100 feet apart. However, placing the traps 50 and 75 feet apart did not increase the proportion of beetles trapped.

Of marked female beetles liberated, from 13 to 28 per cent were recovered in the trap piles. Marked beetles of both sexes remained under the traps from 2 to 20 days, the number gradually decreasing throughout this period.

Judged from the results obtained during the investigations reported in this paper, piles of plant material to provide traps for beetles of *Limonius californicus* cannot be used successfully as an aid in the control of this species, at least not under the conditions existing in southern California.—9-18-38.

Seasonal Variation in the Distribution of Two Species of Symphyla Found in California

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The members of the class Symphyla are widely distributed throughout the world and have been encountered in population studies conducted by Morris (1922, 1927), Thompson (1924), Edwards (1929), Sawa (1930) and Williams (1931). The garden centipede, *Scutigerella immaculata* (Newp.), may occur in great numbers in many localities and has been reported as doing serious damage to growing crops in the United States, England, France, Portugal and the Hawaiian Islands. While working with this species in the delta region of the Sacramento River, the writer noted marked variations in populations. An investigation was therefore undertaken to determine the cause of these fluctuations.

The accurate determination of arthropod populations, particularly the smaller organisms which inhabit the soil, is extremely difficult. In such cases it is possible to determine only relative populations because there are so many factors, such as moisture, temperature, vegetation, soil texture and soil structure which influence numbers and distribution.

EXPERIMENTAL METHOD.—The development of a satisfactory method of taking samples and of separating the symphylans from the soil add to the difficulties of the problem. In this investigation a cylindrical tube 4 inches in diameter with a half inch slit running nearly the length of the tube was used in taking the samples. The surface area of the sample is approximately one-half millionth of an acre. A water flotation method was used in separating the symphylans from the soil. This technique is fully discussed by the

writer in a paper which deals with the biology of the garden centipede (Michelbacher 1938).

Experimental work was conducted in which the efficiency of the water flotation method was checked against a Berlese funnel. This was done in cooperation with L. D. Christenson who is now connected with the U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine. Christenson (1936) has reported on the type of Berlese funnel used. Two surveys were made and the soil samples were taken in the same manner and adjacent to one another. Christenson took one set of samples and ran them through his Berlese funnels, while the writer ran the second set through the water flotation method. The results of these surveys are shown in table 1. Note that many more symphylans were recovered when the water flotation method was used (157 to 17 on the first survey and 217 to 54 on the second survey). In some later work a Berlese funnel was used in a greenhouse population study, and while relatively more symphylans were recovered than reported above, the total collected fell far short of the number obtained by the water flotation method. A Berlese funnel is very satisfactory for studying general soil populations, but because symphylans are easily injured or killed a mechanical method of separating them from the soil is more desirable than one which depends only upon the locomotion of the organism.

The field chosen was located in the Sacramento River delta where conditions were ideal for such an investigation because of the high water table which confined the garden centipedes to the upper soil layers. Counts were made at intervals of about one to two months. The samples were usually taken to a depth of 18 inches, although, when the surface soil was dry, this layer was generally discarded and the sample extended to the 2-foot level. All samples were taken in three parts of 6 inches each, thus giving information on vertical distribution. It is difficult to obtain comparable counts because of changing conditions throughout the year. Selection of locations for sampling is also difficult, because part of the year the land is in crops and the remainder of the time it lies fallow. In order to obtain a fair sampling 12 samples were taken and the locations marked with numbers. (These locations were used in subsequent studies.) Two samples were taken at each location. When the field was in crops, one sample was taken in the row and one in the interspace.

Table 1.—Relative effectiveness of a water flotation method and a Berlese funnel in recovering symphylans from soil samples.

	February 14, 1935			March 12, 1935			
	Water Flotation Method		Berlese Funnel	Water Flotation Method		Berlese Funnel	
Sample Number*	*Scutigerella immaculata*	*Symphylella subterranea*	Total symphylans†	*Scutigerella immaculata*	*Symphylella subterranea*	*Scutigerella immaculata*	*Symphylella subterranea*
1	5	5	0	15	1	2	0
2	1	4	1	6	3	0	0
3	4	13	1	6	2	3	0
4	2	5	1	2	2	3	1
5	23	2	2	26	4	10	0
6	14	7	1	3	3	1	1
7	3	3	1	38	10	4	0
8	3	7	0	4	7	3	0
9	21	8	6	58	6	3	0
10	1	9	3	5	9	1	0
11	1	1	1	4	1	22	0
12	13	2	0	2	0	—	—

* Samples with odd numbers taken along the row (field planted to sugar beets).
† No distinction was made between the two different species.

Results of Investigation.—Two species of symphylans were encountered in the field studied—namely, *Scutigerella immaculata* (Newp.) and *Symphylella subterranea* Michelbacher, which is described in the *Pan-Pacific Entomologist* (Michelbacher 1939). Although consider-

able land in this region has been examined for these organisms, and the former has been found widespread, *S. subterranea* was found only in the field considered in this paper. The two symphylans varied a great deal in their distribution and behavior. It was found that growing vegetation has a strong attraction for the garden centipede and, when plants are present, the centipede is likely to be found in the surface soil in large numbers, while in the absence of vegetation it is found most abundantly in the deeper soil.

Symphylella subterranea, on the other hand, is apparently not attracted by growing plants. Fig. 1 shows the average

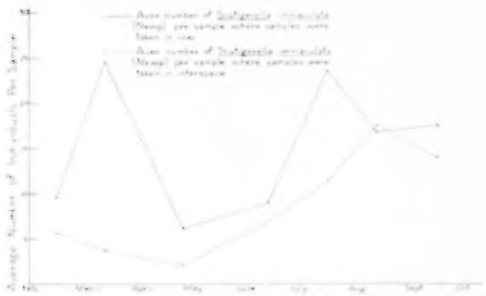

FIG. 1.—Distribution of *Scutigerella immaculata* (Newp.).

number of garden centipedes taken per sample in the rows and interspaces. The land was planted to sugar beets from early February until the end of August. At first most of the garden centipedes were found in the samples taken along the rows, but, as the beets became larger, more and more were found in the interspaces until just before harvest the number found in the rows and interspaces became about equal. Fig. 2 shows the

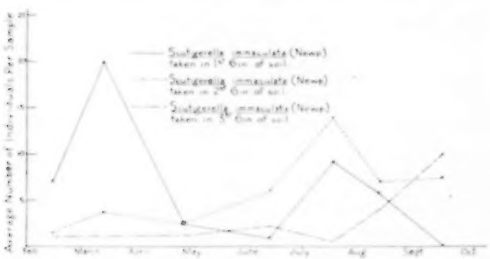

FIG. 2.—Distribution of *Scutigerella immaculata* (Newp.) where samples were taken along the row.

average number of garden centipedes taken per sample for each soil level when the sampling was done in the row, and fig. 3 shows similar data for the samples taken in the interspace. The trend in both cases is very similar except that early in

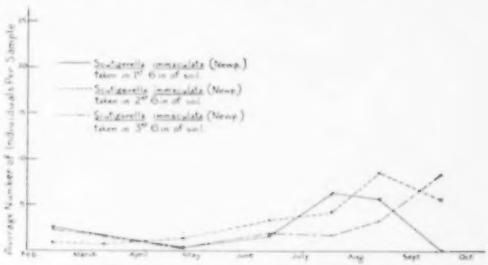

FIG. 3.—Distribution of *Scutigerella immaculata* (Newp.) where samples were taken in the interspaces.

the season relatively more garden centipedes were found in the deeper soil where the samples were taken in the interspace, which further indicates the attraction of growing vegetation. In fig. 4 the average number of *S. subterranea* for samples taken in the rows and interspaces is plotted. The two curves closely follow each other, and the totals obtained in the two series are almost identical (273 and 274). This evidence indicates that growing vegetation has little attraction for *S. subterranea* and that this species is probably a fungus or humus feeder.

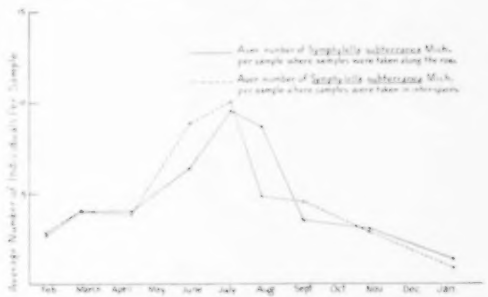

FIG. 4.—Distribution of *Symphylella subterranea*.

There are various other factors aside from vegetation which influence the vertical distribution of the garden centipedes. Moisture and temperature are of very great importance. In summer when they are not feeding, they probably move into the deeper soil to avoid the heat, while in winter the deeper soil favors them because it is warmer. Furthermore, the moisture content of the soil markedly influences the vertical distribution of *Scutigerella immaculata*. This is clearly indicated in

fig. 5 in which the average number of garden centipedes per sample for the 0–6-6–12- and 12–18-inch soil levels are

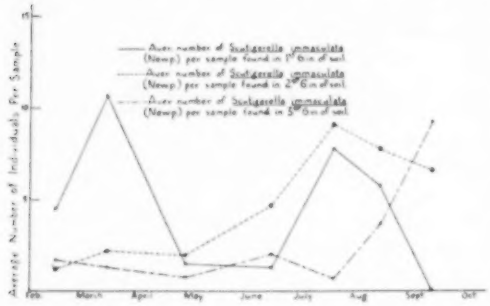

FIG. 5.—Distribution of *Scutigerella immaculata* (Newp.) where the number of individuals taken in samples along the row and interspace is averaged.

plotted by months. In the spring the garden centipedes are concentrated in the surface soil, but as the soil becomes drier they tend to move deeper into it until late in the summer, after the crop is harvested, most of them are found below the 12-inch soil level. The large number of molted skins in the subsoil gives evidence that they spend considerable time in the deeper soil. Soil structure markedly influences the garden centipede distribution. Invariably more are found in an area where the structure is loose than where it is compact. This variability more than anything else is likely to cause deviations in expected results.

Symphylella subterranea is very different in its behavior from *Scutigerella immaculata* (Newp.). It is more sluggish in its movements and prefers the deeper soil. Fig. 6 shows that most *Symphylella subterranea* occur in the lowest level, very few being taken in the first 6 inches.

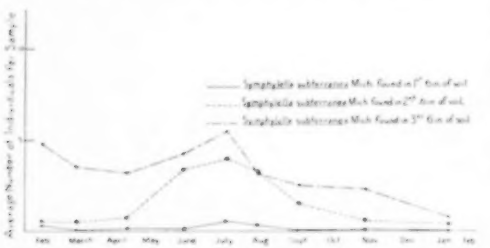

FIG. 6.—Distribution of *Symphylella subterranea* where the number of individuals taken in samples along the row and interspace is averaged.

The lowest garden centipede population can be expected in the spring just before reproduction becomes heavy. An increase takes place during the summer but, as the reproduction period comes to an end, a decline sets in. The field used in this investigation was flooded during the latter part of October, 1935, after which the garden centipede was difficult to find. Because of this abrupt and unnatural reduction in the population of this organism, information on its distribution is not plotted following the flooding period. The greatest population of *Symphylella subterranea* also occurs in the summer. This species is better able to withstand flooding than is *Scutigerella immaculata*, so its distribution is plotted for the entire year.

Because the garden centipede has proved to be an important pest in many localities, it was hoped that these population studies might be of some value in obtaining information on its control. It has become apparent from various studies that natural agencies often reduce the populations to a point where serious damage will not occur. There are areas in which the garden centipede never occurs in sufficient numbers to be destructive. The factors which bring about these marked reductions have not been fully determined. It is possible that bacteria, other parasites, even climatic conditions, or a combination of these may be the cause of sudden fluctuations. The present writer (Michelbacher 1937) carried on an investigation in which the evidence obtained indicated that a crop sequence might greatly influence the garden centipede population. It was found that land devoted to sugar beet culture favored the pest to a greater extent than land cropped to onions. The natural factors which tend to reduce the populations in areas where the garden centipede has been destructive are usually due to influences which have been exerted during the preceding year. It is hoped that future studies will yield more information concerning this subject.

SUMMARY.—Population trends of two species of symphylans having markedly different reactions are considered.

The garden centipede, *Scutigerella immaculata* (Newp.), is very active, and moves readily about in the soil so that its distribution is greatly influenced by such factors as temperature, moisture, soil structure and growing vegetation. It is not able to withstand flooding as well as *Symphylella subterranea* Michelbacher.

Symphylella subterranea is more sluggish in its movements and is confined to the lower soil levels which have a rather stable environment. It is apparently little influenced by the above mentioned factors.

The lowest symphylan populations are likely to occur during the late winter and early spring and the highest populations are likely to occur during the summer after the period of heavy reproduction —8-10-38.

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Factors Concerned in the Deposit of Sprays

*V. The Effects of pH Upon the Deposit of the Oil and Water Phases of Oil Emulsions**†

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In previous reports from this laboratory (Ben-Amotz & Hoskins 1937; Hoskins & Ben-Amotz 1938), it has been shown that the amount of oil which is deposited when a given volume of an oil emulsion is sprayed upon a standard beeswax surface is influenced greatly by the nature and concentration of the accessory substance, often called the spreader, emulsifier or wetting agent. With blood albumin or hemoglobin, both of which enable the aqueous phase to wet the solid readily but which are relatively weak emulsifying agents, the oil deposit passes through a maximum at some intermediate concentration of the accessory substances. With sodium oleate, which possesses the above properties in the reciprocal ratio, there is a continuous decrease in oil deposit as more of the soap is used. A somewhat similar difference in the amounts of emulsion (oil plus aqueous phase) deposited is brought about by these accessory substances. With the proteins this increases as their concentrations increase, but sodium oleate over the range of concentration used (0 to 852 milligrams per gallon) has but little effect upon the amount of emulsion deposited.

In these earlier experiments the pH of the emulsions was not controlled but varied with the accessory substance and its concentration. Since the water used was somewhat basic (pH 8–9) and the oil was slightly acidic these ingredients also had some effect in determining the final condition of the emulsion. From both theoretical and practical points of view it is of interest to learn what effects, if any, will be brought about by purposely establishing the pH at definite values. The work to be reported here was carried out for that purpose.

The forms in which both soaps and

* Contribution from the laboratory of insect physiology and toxicology, Division of Entomology, University of California, Berkeley.

† Valuable assistance in this investigation has been given by laboratory and clerical workers and artists of the Works Progress Administration.

proteins occur in aqueous solutions are altered by variation in the pH. Soap solutions contain much of the soap in the form of ions and are normally slightly basic due to hydrolysis. Addition of an acid, such as hydrochloric, destroys this alkali formed by hydrolysis and favors the formation of more and more undissociated fatty acid so that at a low pH conversion is nearly complete and the original soap is largely destroyed. On the other hand addition of a strong alkali, such as sodium hydroxide, to a soap solution represses the normal hydrolysis and decreases the ionization of the soap molecules so that ionization is at a minimum at high pHs. The situation is complicated somewhat by polymerization and formation of acid soaps (McBain 1920) but the general principle holds that ionization is greatest somewhere in the central pH range.

Proteins contain both acid and basic groups and form a series of salts by means of each, *i.e.*, in solutions of low pH ionized acid salts are formed and in solutions of high pH basic salts are formed which also are largely ionized. At some particular pH, the so-called "isoelectric point," each protein undergoes minimum formation of ionized salts. Since there are many acid and basic groups in the molecule and these are not all equally reactive, there may be an "isoelectric zone" instead of a point and also there is an equilibrium between the normal unionized form of the protein molecule and an internal salt (Borsook & Fadyen 1930) but the situation still prevails that the degree of ionization is at a minimum somewhere in the central pH range.

The effects which emulsifying and wetting agents have upon sprays such as oil emulsions are due chiefly to the ability of their molecules to congregate in the various interfaces concerned and there to assume oriented positions. The tendency of a substance to react in this way is influenced by its degree of ionization under various conditions. It was found by Martin (1935) that the maximum amount of the protein gliadin is adsorbed at the interface glass-aqueous solution at the isoelectric point of the protein but that its effect upon the electrical properties of the interface was at a minimum at this pH. The stability of emulsions of hydrocarbons in aqueous solutions of proteins is greatest at or close to the isoelectric point (Limburg 1926; Friedman & Evans 1931). The emulsifying power of soaps also is influenced by the pH, and the addition of a very little excess alkali was found to promote the emulsification of benzene in sodium nonylate solutions (Harkins & Zollman 1926). The recent work of Langmuir (1936) shows that the composition and wettability of the films which may be placed upon a glass surface when it is moved through a layer of barium stearate lying upon water is dependent upon the pH of the underlying water. Clowes *et al.* (1938) have shown that the thickness of the layer of casein which is formed upon a barium stearate surface when it is dipped into a casein solution varies enormously over the pH range 4.0 to 7.0.

These examples are sufficient to demonstrate that a number of the phenomena concerned in the deposit of oil from emulsions are influenced by the pH and hence it may be expected that the amount of deposit will be affected.

EXPERIMENTAL METHODS.—The spray apparatus, preparation of beeswax surface and spraying procedure were the same as those described before (Hoskins & Ben-Amotz 1938). All results are given in terms of milligrams of deposit per bottle (153 square centimeters lateral area) from sufficient spray applied at 80 pounds per square inch to give 20 cubic centimeters run-off. Total deposit of emulsion and of oil was determined as before after five minutes draining in a saturated atmosphere and after 48 hours drying, respectively.

The same brand of white neutral tank-mix stock oil of 80 seconds Saybolt viscosity and 92 per cent unsulfonatable residue was used. The concentration of oil in the emulsions was 3 per cent by volume in all cases. Three accessory substances were used: hemoglobin prepared from cow's blood as described before; a USP so-called "neutral" sodium oleate, and triethanolamine oleate prepared by combining triethanolamine and oleic acid in the necessary proportions as found by titration of the ingredients with standard acid and alkali, respectively. This latter compound was chosen because it has some of the properties of a soap but tends to decompose to form ordinary soap and free triethanolamine in strongly alkaline solution and to form free oleic acid and a salt

of the triethanolamine in strongly acid solution. Thus it has certain of the reactions of a protein in addition to those of a soap.

The desired pH was established in each case by adding dilute hydrochloric acid or sodium hydroxide to the aqueous solution of the accessory substance. All tests were made with a glass electrode. To insure that the addition of oil did not affect the pH seriously, numerous tests were made of the aqueous phase after separating the oil by centrifuging. In no case did the pH change during the normal time of use by more than a few tenths of a unit.

RESULTS.—The effects of variation in pH from 2.5 to 10.0 upon the total weight of emulsion deposited are shown in fig. 1

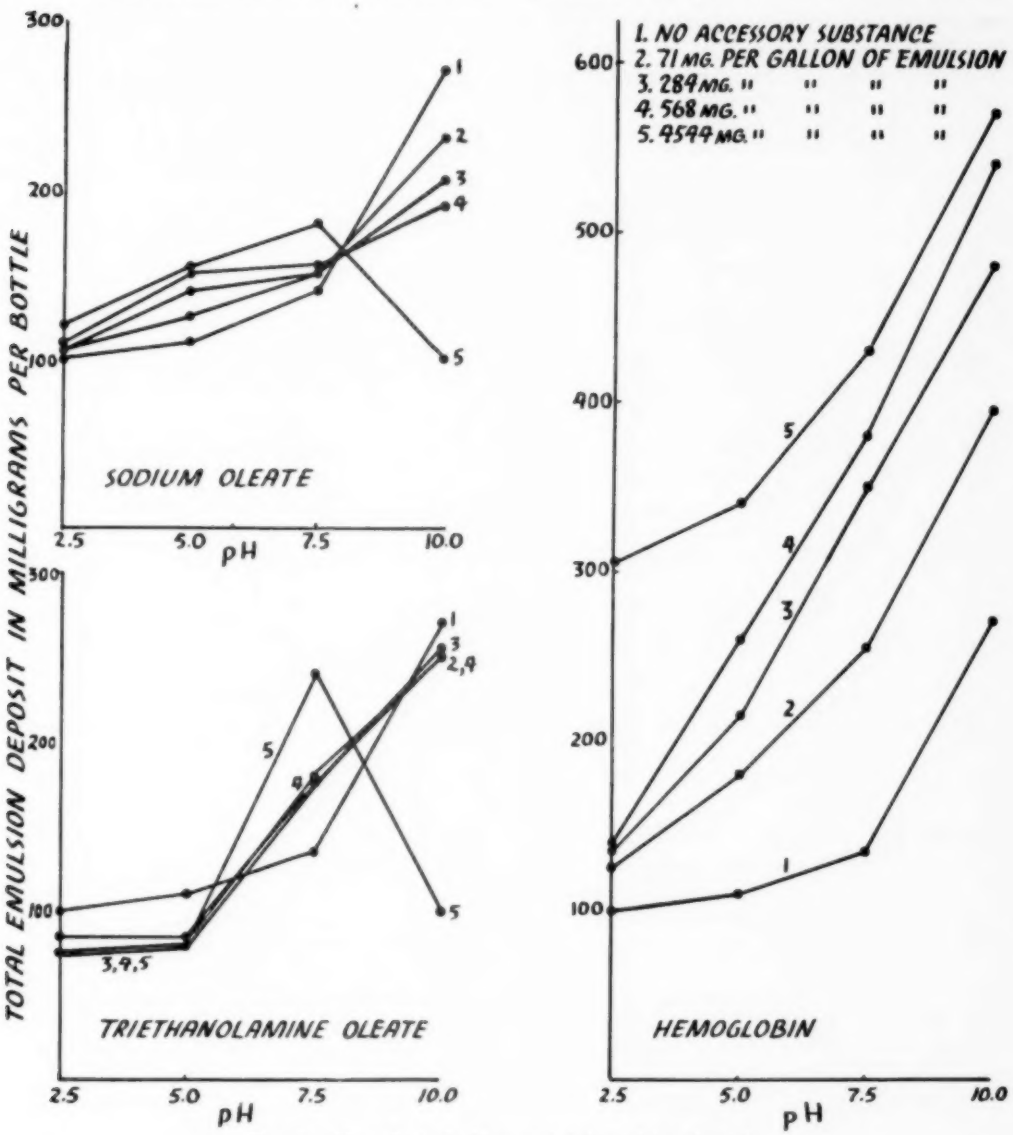

FIG. 1.—The effect of pH upon total emulsion deposit.

for several different concentrations of each accessory substance. To change these to practical units it may be noted that the highest amount (4,544 milligrams per gallon) is equivalent to 16 ounces per 100 gallons.

In fig. 2 are shown the effects of the same variations in pH upon oil deposit

from the various emulsions. The amounts of aqueous phase deposited in each case may be calculated, of course, by subtracting the oil from the total deposit of emulsion. In general the results are similar to those shown in fig. 1, for the oil makes up but a small part of the total deposit in most cases.

DISCUSSION.—It is obvious that the pH of the aqueous phase exerts a strong influence upon the amount of oil or of whole deposit of emulsion at pH 10 did not occur in any case. Hence the results with beeswax are due, at least in part, to an effect of the alkaline aqueous phase upon the surface. The importance of the nature of the solid sprayed has long been recognized by practical spraymen, and Dawsey, Cressman & Hiley (1937) have issued a timely warning against attempts to carry comparative data for oil deposit from paraffin to plant surfaces. An investiga-

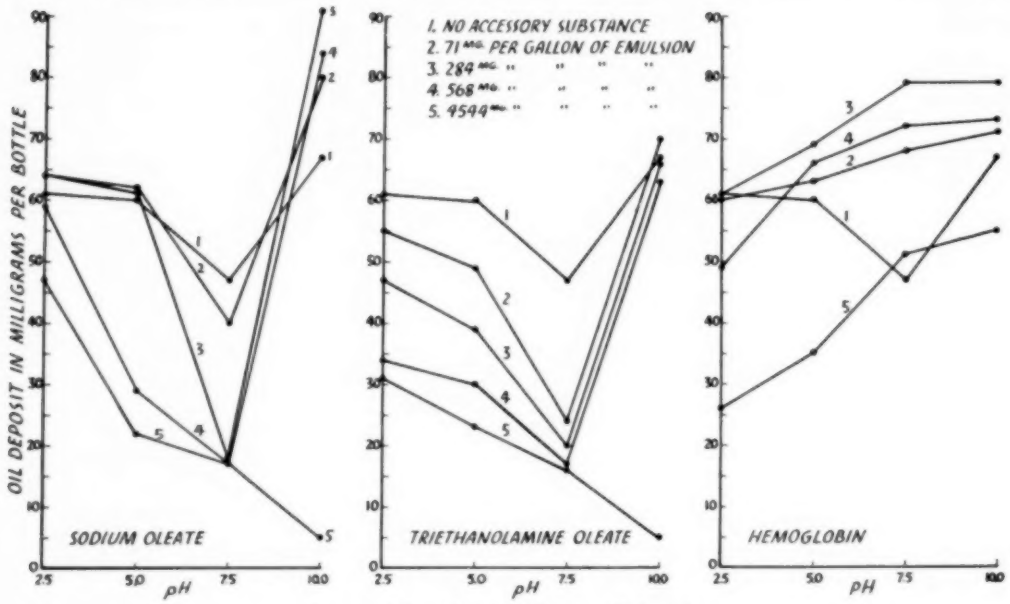

FIG. 2.—The effect of pH upon oil deposit.

emulsion deposited by the sprays used in this investigation. With hemoglobin the two deposits increase in magnitude in a roughly parallel manner as the pH rises but there is no such analogous behavior with the soaps. In fact from pH 2.5 to 7.5 the deposits of soap emulsions increase but the oil deposits decrease sharply. This situation indicates that primary oil deposit is the controlling factor over this pH range. At pH 10 large amounts of emulsion are left upon the sprayed surface by all the preparations and secondary deposit undoubtedly is significant. Whether it accounts quantitatively for the startling increase in oil deposit from the soap emulsions cannot be decided as yet.

The nature of the sprayed surface has an influence upon the behavior of alkaline emulsions. When paraffin wax was substituted for beeswax the increase in deposition of several possible effects of the nature of the surface upon deposit is under way in this laboratory.

Mention may be made of certain individual results on the deposit of oil. The highest amounts of the soaps have a different effect from the weaker concentrations in that there is no reversal of the downward trend between pH 7.5 and 10. Sixteen ounces of soap per hundred gallons of spray is not an excessively large amount for practical spraying. The present results are in agreement with experience in the field that the use of soap often leads to poor deposit. Curve no. 1, of fig. 2, is not really a member of the hemoglobin family of curves for it represents the effect of the acids present in the oil and the soaps formed from them when alkali is added. Hence it is to be expected that curve no. 1 will be consistent in be-

havior with those for added soaps but not with those of hemoglobin.

The results of this investigation indicate that an understanding of the results of adding various accessory substances to oil emulsions cannot be reached unless attention is paid to the pH of the aqueous phase. It has long been suspected that poor results secured in the control of pests in certain California districts may be due to spray water. This has resulted in attempts to "condition" the water but detailed study of all the factors seems not to have been made. An investigation of the pH will probably throw light upon the situation.

SUMMARY.—The deposit of oil upon a standard beeswax surface from emulsions containing sodium oleate or triethanolamine oleate is decreased by changing the pH from 2.5 to 7.5. Upon further changing the pH to 10 the deposit is greatly increased except when large amounts of the soaps are present. When hemoglobin is used, the oil deposit increases with pH throughout the range. With all three accessory substances the total amount of oil emulsion deposited increases as the pH rises. Attention is called to the importance of pH control in practical spraying.—8-10-38.

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Factors Concerned in the Deposit of Sprays

*VI. The Role of Electrical Charges Produced During Spraying**

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Careful attention has long been given by entomologists to the subject of the deposition of sprays, but much remains to be learned of the mechanism whereby insecticides reach and adhere to surfaces.

In the dye industry it has been found that negatively charged fabrics are easily colored by positively charged dyes, but not by those negatively charged. Moore (1921) applied this knowledge to the case of an insecticide upon a leaf surface. He showed that leaf surfaces are negatively charged when in contact with water, and that arsenical insecticides could be prepared which possessed different electrostatic charges when suspended in water. His results showed that positively charged arsenicals were more persistent in adherence to leaves. Since this interesting work was not continued, it may be said that little is known at present concerning the role of electrical charges in the deposit of insecticides. In a previous study on electrostatic charges associated with insecticides, Hoskins & Wampler (1936) obtained evidence to indicate that in addition to the electrical charge upon sus-

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pended particles in a spray mixture, the charge developed upon a surface during spraying must be considered in relation to deposit. The two most important sources of a charge on an object being sprayed are (a) the charge carried on the spray droplets and (b) the charge produced when droplets roll or films of water slide over the surface. It is the purpose of this investigation to determine whether either of these charges is related to the deposit of lead arsenate.

The electrification of liquids by spraying is a well-known phenomenon which has important industrial as well as scientific interest, although no study seems to have been reported of its relation to the deposit of insecticides. Lenard (1915) made a thorough investigation of the spray electrification of water. His researches showed that the cataphoresis of gas bubbles, the charge developed in waterfalls and that due to atomization by impact or bubbling are all intimately connected with the surface condition of the liquid, and result from shearing of the surface layers of the liquid. The very small drops in an aqueous spray were found to be negatively charged, while all those above a certain minimum size were positive in sign. Hence, the main body of droplets, *i.e.*, those that would carry through the atmosphere for some distance and reach a target before evaporating, will usually be charged positively. In an investigation of electrical charges generated by impact of liquids against surfaces, Christiansen (1913) sprayed water and aqueous solutions against a platinum plate and found that charge was proportional to spraying pressure. Elster (1879) studied the production of charge caused by a free stream of water flowing over an isolated surface and showed that the charge developed was proportional to the square of the velocity of the water stream. Evidence was obtained by Elster & Geitel (1887) to show that noticeable differences in sign and intensity of charge occurred when substances of unlike composition were struck by an aqueous spray. These observations are of decided importance here, for leaf, twig and fruit surfaces are not only widely divergent in composition but change continuously during a growing season. Therefore the greatest variety of reactions to sprays may be expected.

APPARATUS AND METHODS.—In the present investigation a study was made (a) of the total charge carried by a spray to a receiver and (b) that given to an isolated plate when it was held in the spray. These conditions roughly correspond to those of practical spraying with no run-off and with heavy run-off respectively. A diagram of the sprayer and accessory apparatus used is shown in fig. 1. A small compressor, *CR*, of the type used for air paint guns provided a source of air to displace spray liquid from the reservoir. From the compressor an air line, of 6 millimeters I.D. glass tubing, was led through two expansion chambers, EC_1 and EC_2, in order to equalize air pressure. One chamber was loosely packed with cotton to remove oil vapor which might come over from the compressor. From EC_2 the air line passed into a galvanized iron reservoir, *RS*, of one gallon capacity. Two lines issued from the reservoir, one carrying liquid, the other air, to a small nozzle, *N*, having an outlet orifice of 1.5 millimeters. By means of a rubber sleeve, nozzles of different size or material could be attached as desired. By adjustment of valves *B* and *C* on both lines the degree of atomization of the spray could be controlled. A mercury manometer, *M*, indicated spraying pressure in centimeters Hg. The rate at which spray was delivered was controlled by the pressure and was approximately 400 cubic centimeters per minute at 20 centimeters Hg pressure. Situated directly below the nozzle was a galvanized iron vessel, *RC*, 13 inches in diameter by 12 inches in height, which was used in determining the total charge carried by the various sprays. In order to insure effective insulation, it was supported upon sulfur blocks. The Faraday cage, *F*, of hardware screen which inclosed the reservoir, nozzle and receiver, *RC*, was cubical in form and 30 inches on a side. It was grounded to minimize the effect of any external electrical fields upon the spray or receiver.

The device employed to measure the charges developed during spraying was a two-stage vacuum tube electrometer using an *FP-54 Pliotron* tube in a high resistance circuit similar to that designed by DuBridge & Brown (1933). The circuit permitted the use of a low sensitivity galvanometer as a null instrument. After balancing the electrometer circuit, the spray charge to be measured was led on to

the grid of the *FP-54* tube through a high resistance of 13 megohms. The resulting deflection of the galvanometer beam was brought back to the null point by applying a potential of equal magnitude and opposite sign to the grid. This potential was then measured directly by switching to a type *K* Leeds and Northrup potentiometer. Thus the charge required to neutralize the charge originally set upon the grid of the *FP-54* tube by the spraying is a direct measure of the potential which has arisen during spraying. In order to secure potentials sufficiently high for accurate reading with all the sprays and targets used, the high resistance mentioned above was necessary. This circumstance made it necessary to insulate the receivers very carefully. Sulfur blocks protected from spray proved to be adequate. The measurement of charge upon droplets depended upon catching all droplets in the large receiver, *RC*, of fig. 1. For these measurements the spray target, *ST*, was removed. When the droplets are caught in a metallic receiver their charge is given up to it, and this charge will continue to increase as more droplets arrive. Since the receiver is connected to the electrometer through a high resistance the charge upon the receiver will be removed at a rate depending on the resistance in the circuit and the rate at which charge is supplied to the receiver, *i.e.*, depending upon the nature of the spray. For any given spray a steady state is reached almost instantly wherein the charge delivered to the receiver becomes a current i_{eq} (the equilibrium current), flowing through the electrometer circuit to earth. Since under these conditions the receiver is at a steady potential, V_{eq} (the equilibrium potential), the current and the potential are related by Ohm's law, *i.e.*, $i_{eq}=V_{eq}/R$, where R is the input resistance. The equilibrium current, i_{eq}, is the number of units of electricity carried each second by the droplets which reach the receiver. If the

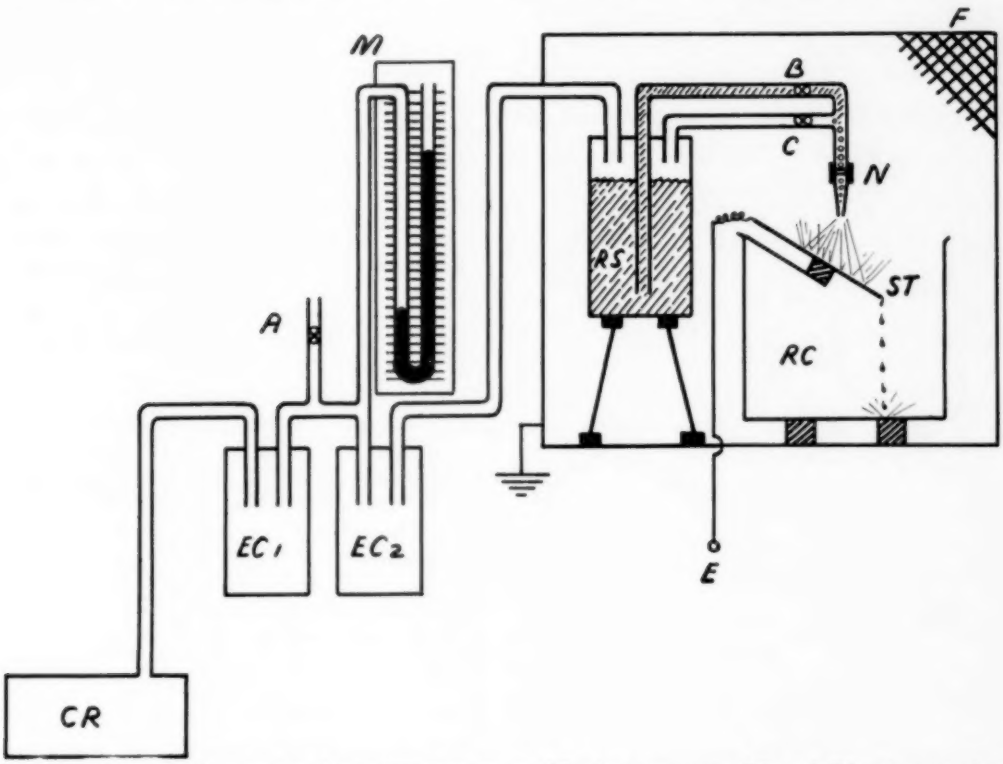

FIG. 1.—Diagram of sprayer and accessory apparatus. *CR*, air compressor; EC_1 and EC_2, air expansion chambers; *A*, valve controlling hydrostatic head; *M*, mercury manometer; *RS*, spray liquid reservoir; *B* and *C*, valves controlling degree of atomization of spray at nozzle *N*; *ST*, spray target; *RC*, spray received; *F*, Faraday cage; *E*, input post of electrometer.

number of droplets were known it would be possible to calculate the charge per droplet, but for the present case this was not necessary. The currents developed during spraying in these experiments were on the order of 10^{-8} to 10^{-9} amperes. For

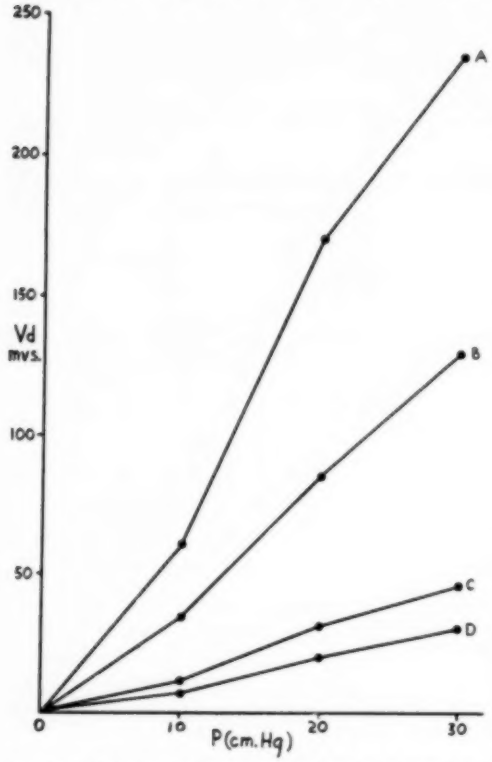

FIG. 2.—Relation between spray droplet charge V_d, spraying pressure P and concentration of electrolyte. Curve A, distilled water; B, tap water; C, 0.001 N aluminum ion solution; D, 0.001 N potassium ferrocyanide solution.

a given spray, i_{eq} is a constant, and from the above equation it is evident that V_{eq} can be given any desired magnitude by varying R. V_{eq} is the term actually read on the potentiometer, and hence R must be kept constant, being fixed at 13 megohm. All spray charge data given have a significance only in terms of this resistance through which the spray receiver was connected to earth.

CHARGES PRODUCED DURING SPRAYING AND THEIR RELATION TO DEPOSIT OF LEAD ARSENATE.—Spray droplet charge V_d in millivolts plotted against spray pressure P in centimeters Hg is shown in fig. 2. Curve A represents distilled water; B, tap water; C, 0.001 N aluminum nitrate solution; and D, 0.001 N potassium ferrocyanide solution. The data clearly show that spray droplet charge is directly proportional to spraying pressure and inversely proportional to electrolyte concentration. These results are in accord with findings of previous writers, *i.e.*, Christiansen (1913) and Nolan (1914). With other solutions and with suspensions of lead arsenate the same conditions occurred, *i.e.*, the total spray charge was diminished with increasing concentration of electrolyte.

After obtaining information upon charge of the spray droplets, attention was next given to the charge arising upon a sprayed object and the changes which occur there during spraying. In fig. 1 the spray target, ST, is shown in place. It consisted of a piece of 18-gauge sheet copper 4 inches square, and was cradled in a wire frame resting on a sulfur block to insure effective insulation. Since the target was not rigidly attached to the cradle, it could be removed and a new one inserted at will. By means of a metal arm fixed on the lip of the receiver, both cradle and target could be adjusted to any desired position in the spray stream, although the latter was fixed at 8 inches from the nozzle in all measurements. Connection from target to electrometer input post (E of fig. 1) was made by a wire carefully shielded from spray. In order to approximate natural plant surfaces, the copper plate was coated with a thin film of refined white beeswax. In spray deposit studies it is important that the surface used be as nearly uniform as possible. In the present case variation in results was obtained with beeswax surfaces aged for different lengths of time, and therefore preparation of the surface was standardized as rigidly as possible. The copper plates were immersed in molten refined white beeswax at 100 degrees C., immediately removed, drained and kept at room temperature in a closed container for 24 hours before being used.

In preliminary experiments it was found that when tap water alone was sprayed upon a beeswax surface no wetting occurred, and the charge developed thereon was highly negative in sign and roughly proportional to the spraying pressure. This situation also prevailed with electrolyte solutions which did not wet the surface, *e.g.*, potassium ferrocyanide solutions. When wetting took

place, as with certain concentrations of aluminum nitrate, the charge was observed to vary with the extent of wetting. The latter was controlled by the concentration of aluminum and for any given solution increased for several seconds after spraying commenced. For most of the runs to be mentioned spraying had continued at 20 centimeters Hg pressure for 30 seconds when the measurements were made. A suspension of C.P. lead arsenate finely ground and freed of all larger particles by settling was used for there is no direct relation between total droplet charge, V_d, and deposit. When the plate charge, V_p, is highly negative, deposit is low and as this charge decreases the deposit increases, reaches a maximum at a low charge and decreases but slightly as the charge passes through zero and becomes slightly positive. The same variation occurs regardless of the very different chemical nature of the solutes.

In seeking an explanation for the different wetting abilities of the various solutions it was found that when aluminum

Table 1.—Relation between concentration of wetter, deposit, charge on sprayed object and wetting.

WETTER	CONCENTRATION IN OUNCES/100 GALLONS	CHARGE ON SPRAY DROPLETS (V_d) IN MILLIVOLTS	CHARGE ON SPRAY PLATE (V_p) IN MILLIVOLTS	DEPOSIT OF LEAD ARSENATE, IN MILLIGRAMS	DEGREE* OF VISUAL WETTING
None (tap water)		+166.8	−150.0	0.5	0
Commercial blood albumin	0.50	+143.0	− 94.6	0.9	x
	0.75	+112.5	− 68.2	2.5	xx
	1.00	+100.0	− 44.5	3.6	xxx
	2.00	+ 91.6	+ 28.3	3.0	xxxx
	4.00	+ 82.7	+ 32.2	2.8	xxxx
	8.00	+ 75.4	+ 29.4	2.9	xxxx
Aluminum nitrate	1.00	+ 50.0	−110.0	0.4	0
	1.25	+ 47.2	− 38.7	3.4	xxx
	1.50	+ 40.2	+ 22.4	2.7	xxxx
	3.00	+ 24.5	+ 24.1	2.9	xxxx
Commercial sulfated alcohol	3.00	+ 78.7	−145.7	0.6	0
	6.00	+ 70.2	− 25.2	3.8	xxx
	12.00	+ 61.3	+ 17.5	2.6	xxxx
	24.00	+ 55.9	+ 18.6	2.7	xxxx

* 0 denotes no wetting, x that droplets begin to flatten, xx that elongation of the droplets begins, xxx that droplets coalesce into rivulets and xxxx that complete film formation has occurred.

study of the effect of spray charge upon deposit. The concentration was 2 pounds per 100 gallons in all cases. After being sprayed, the tared plates were shaken to remove excess liquid and dried for 24 hours before being reweighed. Thus the deposit determined was that which has been called primary in the case of oil emulsions (Smith 1933, and Hoskins & Ben-Amotz 1938). Primary deposit is more useful in the present case because it is uniformly distributed and is not influenced by the heavy clumps left as a secondary deposit when the excess adhering liquid dries. In table 1 the results are shown for suspensions of lead arsenate in tap water and in solutions containing varying amounts of aluminum nitrate or of the commercial wetting agents, blood albumin and a sulfated alcohol. Obviously nitrate was added to distilled water no wetting occurred and deposit of lead arsenate was low in every case. These suspensions differed in pH for with distilled water all were below pH 5, whereas when tap water was used the pH was slightly below neutrality. This difference is due to the original basicity and appreciable buffering power of the tap water, while the original slight acidity of the distilled water was enhanced by hydrolysis of the aluminum salt. However, pH is not the sole factor, for suspensions in tap water made to definite pHs from 4.0 to 9.0 did not wet and gave low deposits, as shown in table 2. It can be seen that the deposit from these suspensions bears no relation to either total droplet charge or plate charge.

It was noted that whenever wetting of

Table 2.—Variation in charge, wetting and deposit as affected by pH of spray suspensions.

pH of Spray	Charge on Spray Droplets (V_d) in Millivolts	Charge on Spray Plate (V_p) in Millivolts	Degree of Visual Wetting	Deposit of Lead Arsenate in Milligrams
4.0	+ 14.0	− 65.0	0	0.6
5.0	+ 52.5	− 10.2	0	0.5
6.0	+151.2	+ 98.7	0	0.5
7.0	+162.0	−105.1	0	0.4
8.0	+108.5	−204.3	0	0.5
9.0	+ 58.5	−225.4	0	0.5

a sprayed surface began to occur, the original high negative charge thereon rapidly decreased, and upon complete film formation always dropped to a low value. A typical progression in wetting by sprays containing different concentrations of aluminum is shown in fig. 3. The beeswax coated plates were photographed while still being sprayed, by use of a photographic arrangement permitting one-thousandth of a second exposure (Craig 1936). Each plate was sprayed 30 seconds before being photographed. Plate A was sprayed with a solution containing 1 ounce, B with 1.25 ounces and C with 1.50 ounces $Al(NO_3)_3.9H_2O$ per 100 gallons. These concentrations correspond to 0.20, 0.25 and 0.30 millimols aluminum per liter. Plate A illustrates the inception of wetting and shows the formation of large drops which are beginning to elongate on the surface, B presents the state wherein large drops have coalesced into rivulets, and C the formation of a complete film. A film of liquid so produced by aluminum persisted even when the plate was subsequently sprayed for long periods at high pressures with water alone, which does not adhere to beeswax. This indicates that the aluminum is held strongly on the wax surface. However, if a surface after having been wetted with an aluminum spray is sprayed with a solution containing the polyvalent negative ferrocyanide ion, the film is destroyed at once and a typical non-wetting condition results.

When plant leaves were sprayed the results were closely akin to those obtained

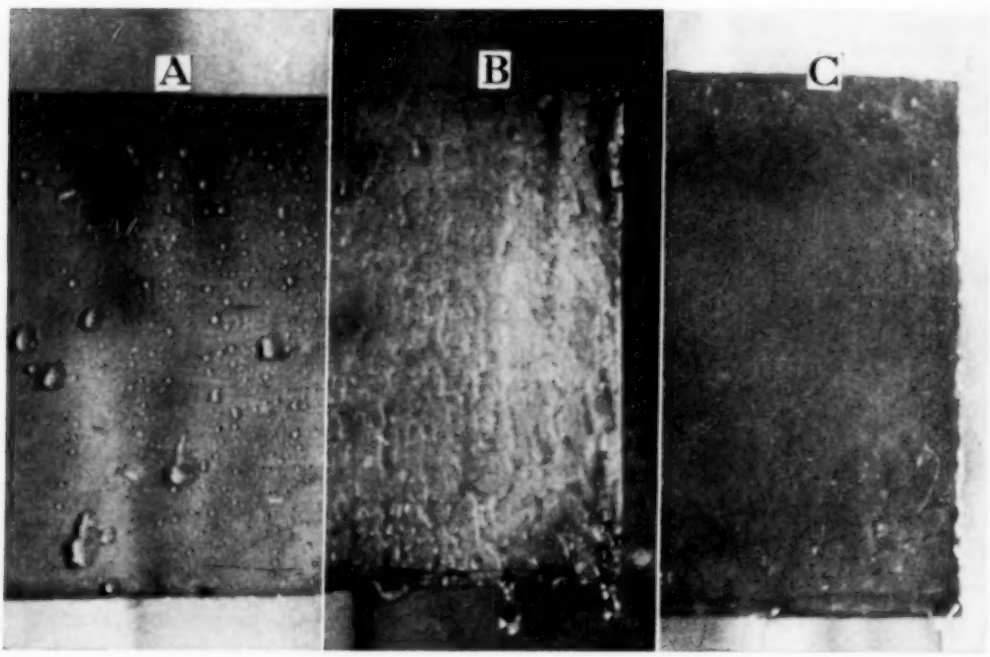

FIG. 3.—Showing progressive wetting of beeswax surfaces with sprays containing different amounts of aluminum. A, 1 ounce; B, 1.25 ounce; and C, 1.50 ounce aluminum nitrate per 100 gallons.

with beeswax surfaces. Large leaves of *Cuba japonica* and *Aurelia sp.* were selected, care being taken to choose those leaves possessing the smoothest waxy surfaces. A leaf was placed in position on the cradle and connected to the electrometer by means of a wire clip fastened to the edge of the leaf. Lead arsenate suspensions in tap water failed to wet the leaf surface, and the resultant charge was high, but, with the same concentration of aluminum which produced wetting on beeswax, wetting took place even more rapidly on the leaves. As wetting increased the charge became less and reached a final minimum value at complete film formation. After leaves which had been completely wet in this manner were allowed to dry, a thin uniform film of lead arsenate was visible upon the surface.

EFFECT OF EXTERNALLY IMPOSED POTENTIALS UPON WETTING AND DEPOSIT.—It has been shown that there is no apparent relation between deposit of lead arsenate and the total spray charge or the plate charge as they occur in spraying. Since it is experimentally possible to intensify these respective charges the effect of imposing potentials was tested. If the metal spray nozzle is connected with a source of direct current, the sign and magnitude of charge upon the spray droplets may be altered, and in the same manner any charge may be placed upon the object being sprayed. The results of this experiment are given in table 3. The beeswax plates were sprayed and weighed as described before. Regardless of the sign or magnitude of charge applied to the nozzle or plate there was not the slightest effect upon wetting nor upon retention of lead arsenate on the sprayed surface. Suspensions containing aluminum wet the surface as usual, increase in deposit being related primarily to wetting. Potassium ferrocyanide was used because it ionizes in such a way as to confer a high negative charge upon the suspended particles of lead arsenate (Hoskins & Wampler 1936), but no increase in deposit occurred even when a very strong positive charge was applied to the plate. It should be noted that the highest potential developed during spraying was 225 millivolts and the highest imposed was 150 volts. Thus a vastly greater imposed potential had no effect upon deposit.

Table 3.—Effect of potentials externally applied to spray droplets and sprayed object upon wetting and deposit.

CONCENTRATION OF SALT IN OUNCES PER 100 GALLONS	POTENTIAL APPLIED TO NOZZLE IN VOLTS (D.C.)	CHARGE ON SPRAY DROPLETS (V_d) IN MILLIVOLTS	POTENTIAL APPLIED TO PLATE IN VOLTS (D.C.)	DEPOSIT OF LEAD ARSENATE IN MILLIGRAMS	DEGREE* OF VISUAL WETTING
Tap water alone	0	+166.8	0	0.6	0
	+150.0	+312.6	0	0.5	0
	+ 90.0	+257.2	−45.0	0.5	0
	− 45.0	+109.0	+90.0	0.5	0
	− 90.0	+ 43.2	+45.0	0.4	0
	+ 45.0	+210.0	−45.0	0.5	0
	−150.0	+ 7.0	0.0	0.5	0
Aluminum nitrate					
2.0	0	+ 40.0	0	2.9	xxxx
2.0	+ 90.0	+135.7	−45.0	2.8	xxxx
2.0	−150.0	− 97.5	0	2.8	xxxx
2.0	+ 45.0	+ 90.7	−90.0	2.9	xxxx
2.0	− 45.0	− 2.6	+90.0	2.7	xxxx
Potassium ferrocyanide					
2.0	0	+ 29.1	0	0.4	0
2.0	+ 45.0	+ 70.3	−90.0	0.5	0
2.0	− 90.0	− 55.2	+45.0	0.4	0
2.0	+150.0	+175.7	0	0.5	0

* 0 denotes no wetting; xxxx that complete film formation has occurred.

DISCUSSION.—Reasoning from the well-known principle concerning the role of electrostatic charges in the deposit of dusts upon surfaces, *i.e.*, that like charges repel and unlike charges attract, it is logical to ask if the same principle will

apply to the deposit of particles from aqueous suspensions. It is apparent from the data given that the principle does not apply in this case. The situation of a particle surrounded by a liquid shell is very different from that of one floating free in the air, such as a dust particle and it is doubtful, on theoretical grounds, that the imposition of any potential however great upon spray droplet or sprayed object would cause an increased deposit. The latter is affected by the electrical forces located in the transition zone from sprayed surface to liquid and these do not necessarily have any relation to the potential produced upon the whole object when it is sprayed. Wetting is the most important factor in deposit. The action of aluminum in producing wetting is not well understood, but a probable mechanism may be suggested. Aluminum ion exists as such only in very acidic solutions, at a pH far below that normally encountered in spraying. At a pH near neutrality, hydrolysis of aluminum salts takes place according to the reaction $Al^{+++}+3HOH \rightarrow Al(OH)_3+3H^+$. Aluminum hydroxide is a compound well known for its hydrophilic properties, and its formation and collection at the interface during spraying could very well result in wetting. The fact that pH of the spray suspension must be properly adjusted to permit wetting to occur supports the above stated suggestion. Unfortunately no direct methods are available for determining the concentration of aluminum ion or of colloidally dispersed aluminum hydroxide in solution in the spray liquids, and hence a quantitative explanation of its effects upon wetting cannot be given at present.

The information given here points definitely to the solid-liquid interface as the site offering the most promise in investigations on spray deposits. True wetting involves real contact between solid and liquid, and consequently is concerned with forces acting over very short ranges, *i.e.*, on the order of molecular diameters. It is probable that with the relatively macroscopic methods herein employed only a rough index of the really important potentials concerned with surface-liquid relations was obtained. It is not possible to apply the usual terms used to explain wetting, such as angle of contact and increase in area of a surface covered by a given volume of liquid, for such information is obtained usually with liquids in a static condition, and is difficult to apply to the events taking place when spray is being applied to a surface. The solid-liquid interface is a region of abrupt change and rapid alteration in electrical potentials. The addition of electrolytes and typical wetting agents affect these potentials and hence affect wetting of the surface. These changing potentials can be measured by a number of methods, such as that of streaming potential and thereby an avenue of investigation is opened which permits quantitative examination of surface charges under dynamic conditions. Frumkin *et al.* (1932) have given data to show that definite relations exist between the charge of a surface and the degree of spreading of a liquid upon that surface. As measured in the present investigation, the charge upon the sprayed object is always low when wetting occurs. It is conceivable that measurement of the rate at which the charge upon a surface changes during spraying may be a valuable method for the quantitative study of wetting. Langmuir's report (1938) that the retreat of aqueous solutions from hydrophobic surfaces leaves the latter highly charged, while surfaces which are wet by liquids have low intensities of charge, indicates that the study of potentials arising at solid-liquid interfaces can be very profitably pursued in relation to spray deposit problems. Work along such lines is now in progress in this laboratory.

SUMMARY.—Electrical charges are produced on droplets by the rupture or atomization of liquid columns as well as by impact and splashing of droplets against a surface. The rolling of droplets and sliding of films of liquid over surfaces also produce charges thereon. A small compressed air sprayer was developed for production of spray, delivering 400 cubic centimeters per minute at a pressure of 20 centimeters Hg. Charges carried on droplets are given up to the sprayed surface, and if the latter is connected through a high resistance to the earth a steady current and potential are established as long as the spray remains uniform. The potential has been measured by use of a vacuum tube electrometer circuit. The voltage, V, can be given any magnitude by varying the input resistance, R, as is

seen from the expression, $V = IR$. R remains fixed throughout at 13 megohms. Currents developed during spraying were on the order of 10^{-8} to 10^{-9} amperes. Spray droplet charge is directly proportional to spraying pressure and inversely proportional to electrolyte concentration. On sprayed beeswax surfaces charge varies greatly both in sign and magnitude, depending on kind and amount of electrolyte present and upon hydrogen ion concentration of the spray. Wetting of the wax surface occurred when aluminum nitrate was present in certain concentrations in the spray suspension, but this wetting would not take place unless the pH of the solution was properly adjusted. A mechanism is suggested whereby aluminum ion operates to produce wetting. When wetting occurred, the magnitude of charge upon the sprayed surface decreased steadily as wetting progressed, and at complete film formation the charge always reached a minimum value. This charge-wetting relationship held for several wetters of widely divergent chemical composition. Deposit of lead arsentate is related to degree of wetting but not to charge upon spray droplets or sprayed surface. The results obtained when plant leaves were sprayed closely paralleled those with beeswax surfaces. Retention of lead arsenate upon the beeswax surface could not be increased by charging spray droplets and sprayed surface with external potentials of unlike sign, and wetting was likewise unaffected. Wetting controls deposit, and in its absence deposit is low. There is no relation between the deposit of lead arsenate, total charge of the spray droplets nor total charge of the sprayed object.—8-10-38.

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Field Experiments for Control of the Beet Leafhopper in Idaho, 1936–37*

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The beet leafhopper, *Eutettix tenellus* (Bak.), is the vector of curly top, a disease of sugar beets, beans, tomatoes, cucurbits and other crops. This insect breeds in

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desert areas, where it completes the early-summer generation on the spring annuals. These annuals mature about the time the spring generation is developed, and the insect migrates to suitable summer host plants, which are found in certain cultivated and abandoned-farm areas.

Investigations conducted by Giddings,* of the Division of Sugar Plant Investigations, Bureau of Plant Industry, U. S. Department of Agriculture, have shown that the smaller the beet, the more susceptible it is to curly top, or, in other words, that resistance increases with age. Previous experience, when varieties susceptible to curly top were in use, discouraged efforts to spray sugar-beet fields for leafhopper control. However, the new, curly top resistant varieties show appreciable resistance even in the small seedling stage, and with their introduction for commercial planting in south central Idaho it was deemed advisable to conduct investigations in chemical control to determine if the beet plants could be protected from beet leafhoppers during the period of relatively low resistance.

FIG. 1.—Spraying beets for the control of the beet leafhoppers, Castleford, Idaho, June 13, 1936.

Wallace & Murphy (1938) studied the viruliferous percentages of the spring generation leafhoppers infesting beet fields in six consecutive years. They found that the proportion that was viruliferous ranged from as low as 4 per cent in one year to as high as 67 per cent in another. In years when a low percentage of the incoming leafhoppers are viruliferous, a longer time is required for the disease to reach the epidemic stage. In such years it would appear that chemical control of the leafhoppers for a period following infestation would further retard the increase of curly top in the fields.

Campbell (1937), working in California, obtained decreases of 87.8, 97.6 and 98.2 per cent in beet leafhopper populations, with pyrethrum in oil sprays, and points out that within the last five years materials and equipment for vaporized spraying have been so developed that successful commercial control of the beet leafhopper is assured.

Control experiments by V. E. Romney† of the Bureau of Entomology and Plant Quarantine, in cooperation with beet-

* Unpublished data by N. J. Giddings.

† Unpublished data.

seed companies in the southwest, have demonstrated the feasibility of beet leafhopper and curly-top control under fall conditions. These results need additional confirmation.

With funds appropriated by the state of Idaho and under a cooperative agreement between the Governor of Idaho, the University of Idaho Agricultural Experiment Station and the U. S. Department of Agriculture the following experiments were conducted.

MATERIALS.—The spray materials purchased consisted of concentrated pyrethrum extract to contain not less than 2.0 grams of pyrethrins in each 100 cubic centimeters; summer spray oil no. 2, light-medium, containing a minimum of 92 per cent unsulfonated residue and having a viscosity of 60–65 seconds Saybolt universal; kerosene containing a minimum of 98 per cent unsulfonated residue and having a viscosity of 32 seconds Saybolt universal.

The materials used in 44 of the 46 experiments in 1936 consisted of a mixture of pyrethrum, oil and kerosene, or pyrethrum and kerosene, in ratios of oil to pyrethrum from 25 to 1 to 50 to 1. The other two sprays consisted of a 4 per cent

FIG. 2.—Rear side view of sprayer showing mounting on trailer and tractor attachment permitting quick turning. Photographed July 1, 1937.

lauryl thiocyanate in oil and pyrethrum 2 per cent plus lauryl thiocyanate 2 per cent in oil.

The pyrethrum, oil and kerosene used in 1937 were similar to the materials used in 1936. The derris root powder contained 3 per cent rotenone, the nicotine sulfate contained 40 per cent nicotine and the free nicotine contained 50 per cent free nicotine.

METHODS.—The pyrethrum in oil and kerosene, pyrethrum in kerosene, and free nicotine in oil were measured out and

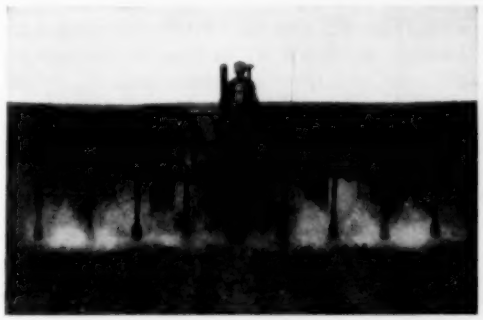

FIG. 3.—Spraying beets for the control of the beet leafhopper, Buhl, Idaho, June 10, 1937.

mixed in steel drums or cans and were stored in these until used. The free nicotine in oil was strained and the brown aqueous deposit discarded. The derris and nicotine sulfate sprays were made up in the field while the spray tank was being filled.

The applications of insecticides in oil were made with a blower-type vaporizer mounted on a tractor as illustrated in fig. 1. This four-nozzle vaporizer covers eight rows at a time. The material was applied at about 8 pounds pressure. The applications of insecticides in water were made with a quadruplex sprayer mounted on a trailer and attached to a tractor, as shown in fig. 2. This 24-nozzle sprayer covers eight rows at a time, fig. 3. The material was applied at 300 pounds pressure. The rate per acre was varied by driving the tractor in different gears to increase or decrease the ground speed.

In 1936 preliminary experiments were conducted in cooperation with growers on the western edge of the cultivated area near Buhl and Castleford. In 1937 the experiments were carried out on leased land five miles west of Buhl. The fields were selected on account of soil fertility and location. Both seasons the fields were situated very close to the leafhopper breeding grounds and were ideal for heavy infestation, as excellent spring host plants for leafhoppers were found in the sagebrush adjoining the farms. The fields se-

lected for spraying in 1936 were divided into plots, the size and number of plots per field being determined by the size and arrangement of the field. In 1937 the field selected was divided into one-half acre plots. Eight rows of Red Mexican beans served as a buffer between the beet plots. Each beet plot was divided into four subplots. The R. and G. Old Type seed was planted on April 17 in the northeastern and southwestern subplots, and U. S. 12 seed (Owen *et al.* 1938) in the southeastern and northwestern subplots.

In 1936 the infestation counts were taken just before the spray was applied and again in about 24 hours, whereas in 1937 the counts were taken before the spray was applied and again after each application, but the period after the first two applications was prolonged, by wind, longer than 24 hours. The population counts were made by means of the Hills' sampling cage, fig. 4. The first season 100 beets, or, where thinning had not been done, 100 feet of row, were sampled at random in each plot. The latter season 100 beets were sampled for the first four counts and 52 beets for the last four counts. The beets were sampled by a predetermined method to give the same number of samples for each of the four subplots of each plot to make the sampling uniform for all plots.

Each plot was subdivided into four parts for the disease counts. Rows 4 and 8 were arbitrarily selected for counting diseased beets. The beets to be counted were staked out so that beets in the same relative position would be used in each plot and so that the same beets in each plot would be used for the subsequent counts. In each plot 100 beets of each variety were observed for total disease and 200 beets of each variety were observed for obvious disease. Total disease includes all those beets which upon close examination showed any symptoms of curly top. Obvious diseases includes those beets showing rather pronounced curly top symptoms which could be determined without close examination.

LEAFHOPPER POPULATIONS.—The first systematic observations to determine the appearance of beet leafhoppers in beet fields in 1937 were made on May 20. These revealed that a small number of overwintered females had already entered the fields located on the western edge of the cultivated area near Buhl and Castleford. A general, gradual increase in the infestation occurred from May 20 to June 1, when an average of 27 leafhoppers per 100 beets was recorded. By June 3 the average infestation had increased to 90 per 100 beets, as shown by the commercial fields in fig. 5. This large increase definitely marked the spring migration into the cultivated area. From June 3 to 14, inclusive, a marked increase in population occurred. The number of leafhoppers increased from an average of 501 per 100 beets on June 14 to 965 on June 16 and from 1,227 on June 18 to 2,557 on June 21, and to 2,939 on June 23, when the peak was reached.

The data presented in fig. 5 show very little difference in beet leafhopper infestation on nonresistant R. and G. (Old Type)

FIG. 4.—Sampling beets for beet leafhopper populations with a Hills' standardized cage.

and resistant (U. S. 12) strains of beets until June 23, when the nonresistant plants began to "break down" with curly top, fig. 6. The average populations on nonresistant beets were 3,034, 2,650 and 1,154 on June 23 and 24 and July 9 as compared with 3,940, 3,594 and 5,004, respectively, on resistant beets.

Fig. 5 illustrates, by comparison, the average infestation on nonresistant and resistant beets in the experimental plots, together with the average of six commercial plantings in the same general area. The commercial plants are all resistant varieties and probably include U. S. 34 and A-600.

Fig. 5 also illustrates how the infestation built up in each situation until June 23, when the peak was reached on commercial plantings and nonresistant beets in the plots, and how the populations on resistant beets in the plots continued to increase. The figure shows the approximate date on which the nonresistant beets "broke down" and the leafhoppers began to move from the Old Type to the resistant beets. The population curve for the Old Type decreased after the "breakdown," whereas for the U. S. 12 it increased.

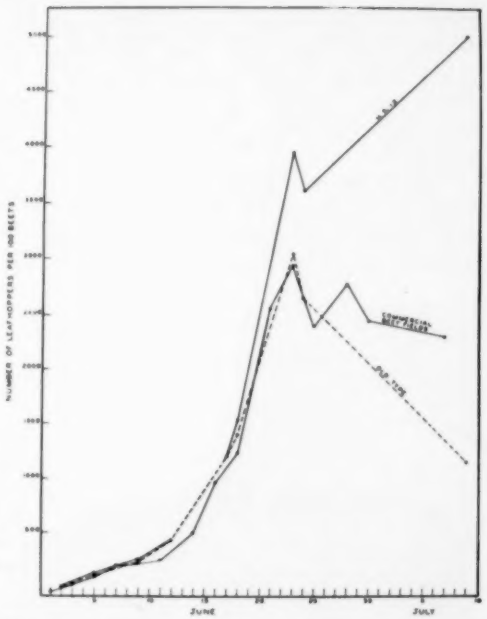

FIG. 5.—Graph showing the average number of beet leafhoppers per 100 beets on Old Type and U. S. 12 in the check plots as compared with commercial plantings within the same area for 1937.

EXPERIMENTAL DATA.—The experimental data for 1936 are not presented in table form since only leafhopper kill was recorded, the summary of which is given in the text.

The insecticides used, number of applications, date applied, per acre application and the results in 1937 are presented in

Table 1.—Results of experiments to control beet leafhoppers in south-central Idaho, 1937.

MATERIAL USED	APPLICATIONS	DATE OF APPLICATION, 1937	GALLONS APPLIED PER ACRE	ADULT INFESTATION			
				Number After Spraying	Number in Check	Number Increase or Decrease	Per Cent Change
Kerosene 20 gal.	1	June 4	6.8	155	175	− 20	−11.43
Oil 10 gal.	2	June 10	8.0	411	444	− 33	− 7.43
Free nicotine 2%	3	June 17	7.8	920	1,433	−513	−35.80
	4	June 23	7.0	2,160	3,343	−1,183	−35.39
Derris (3% Rotenone), 2 lb.	1	June 4	113.3	202	175	+ 27	+15.43
Aresket, 6.4 oz.	2	June 10	110.7	524	444	+ 80	+18.02
Water, 50 gal.	3	June 17	149.5	1,566	1,433	+133	+ 9.28
	4	June 23	149.0	3,269	3,343	− 74	− 2.21
Kerosene 20 gal.	1	June 4	7.8	53	175	−122	−69.71
Oil 10 gal.	2	June 10	5.7	286	444	−158	−35.59
Pyrethrum 1 gal.	3	June 17	7.3	265	1,433	−1,168	−81.51
	4	June 23	8.0	569	3,343	−2,774	−82.98
Nicotine sulfate 1 qt. 40%	1	June 4	109.3	238	175	+ 63	+36.00
Summer oil emulsion 1 gal.	2	June 10	113.3	565	444	+121	+27.25
Water 100 gal.	3	June 17	151.0	1,202	1,433	−231	−16.12
	4	June 23	139.0	3,056	3,343	−287	− 8.59

table 1. The adult beet leafhopper infestation in the check and treated plots is given in fig. 7. The migration of the beet leafhopper into the check plots and commercial fields situated nearby is presented in fig. 8.

The table and figures are self-explanatory as far as actual data are concerned, but other important factors should be considered before conclusions are drawn.

FIG. 6.—Twelve rows of U. S. 12 beets on the left, 12 rows of R. and G. Old Type on the right. The majority of nonresistant beets have died.

DISCUSSION OF RESULTS —Records show that during 1936 the highest kill was 97.83 per cent and the lowest was 35.25 per cent, for the 46 experiments. The infestation counts showed that in 6 of the 17 check plots the population increased after spraying, while other check, or untreated, plots showed a substantial reduction. This would indicate a considerable shifting or movement of the leafhoppers as was shown when one field was sprayed while the wind was from the south. The rows of the field ran east and west. On the north and south sides of the field were check, or untreated, plots. The spray was applied late in the afternoon and there was considerable drift to the north. Population counts the next day showed an increase of 31.82 per cent for the south check plot and a decrease of 52.05 per cent for the north check plot. This would indicate that drifting of the spray material across an unsprayed plot tends to disturb the leafhoppers so that they move out of the plot.

The evidence indicates that the 50-to-1 and 40-to-1 ratios of oil to pyrethrum are too large, and that best results are obtained at ratios of 25 to 1 and 30 to 1. In general the percentage of leafhoppers killed increased as the pyrethrum content increased. The percentage killed increased as the application per acre increased from 5 to 6 to 7 to 8 gallons.

The magnitude and rate of migration of this insect into beet fields are very important. The period between the time the material is applied and the results are recorded is also an important factor, especially with an insect as active as the beet leafhopper. A glance at table 1 or fig. 7 will show a decrease in infestation after each application in which oil and free nicotine, and oil and pyrethrum were applied whereas in the derris and nicotine sulphate plots decreases in insect population occurred only after the fourth and the

third and fourth applications, respectively. The infestation counts after the first, third and fourth applications were taken about 24 hours after the application was made, whereas cool, windy weather delayed the counts on the second application for about 48 hours, which undoubtedly affected the spray results to a considerable extent. The infestation curve for the check plots shows an increase of 137 per cent from June 2 to 5, a 59 per cent increase from June 9 to 12 and 19 per cent increase from June 17 to 18, whereas a 4 per cent decrease occurred from June 23 to 24. The first two increases occurred over a three-day period while the two following changes took place within one day. The rapid influx of leafhoppers, particularly during the first two spray applications, affected both treated and check plots and masked the effects of the spray.

Early in the season curly top does not develop and show up for some time after the plants are infected. Owing to the low populations of leafhoppers in 1936 the percentage of curly top that developed in

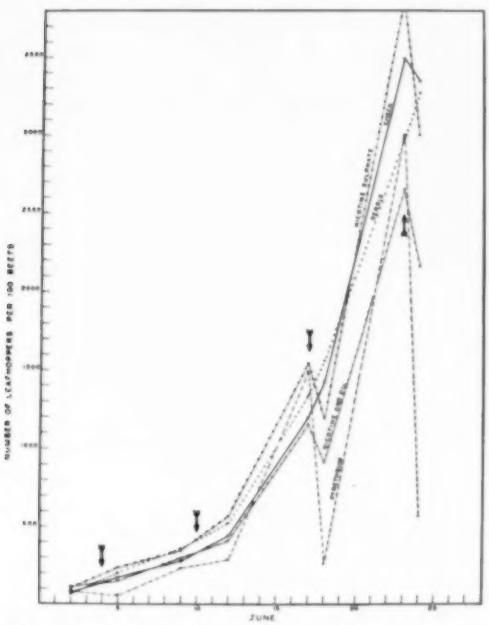

FIG. 7.—Graph showing the beet leafhopper infestation in the sprayed plots in comparison with the check plots for 1937. Arrows indicate the date of spraying.

the fields was small. The highest amount of obvious disease was 25.2 per cent. The leafhoppers were in the fields from May 25 on and, since spraying was unavoidably delayed until June 10, the insects had plenty of time to infect a percentage of plants. In other words, spraying was begun too late to reduce populations of the leafhoppers before they had time to transmit curly top to the beets, and no appreci-

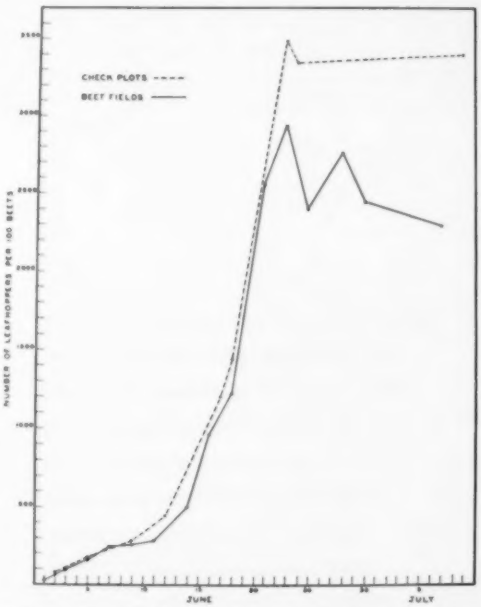

FIG. 8.—Graph showing the spring migration of beet leafhoppers into the check plots and commercial fields during 1937.

able difference in disease between check and sprayed plots was evident or could be expected. The only definite information obtained from the field spray tests relates to the effectiveness of various combinations of insecticides in killing adult leafhoppers.

In order to determine if the 1937 spray experiments were of value in reducing curly top infection in the various plots, disease counts were made in each plot on July 6 and 7, and again on July 26 and 27.

The results of the disease counts show no significant difference between the various treated plots, or between the untreated plots. Even where four applications of a pyrethrum-oil spray were used, there was no curly top reduction below the average for all plots.

On July 6 and 7 the average total disease in the Old Type beets was 96.6 as compared with 81.1 for the U. S. 12 beets, whereas on July 26 and 27 the total disease increased to 100 per cent in Old Type and to 97.1 per cent in U. S. 12. The aver-

age obvious disease at the time the first count was made was 89.3 per cent in Old Type as compared with 39.3 per cent in U. S. 12. Twenty days later the obvious disease in Old Type had increased to 99.6 per cent and in U. S. 12 to 81.6 per cent.

By comparing the percentage diseased in Old Type and U. S. 12 varieties one readily sees that the disease developed in Old Type very much faster than in U. S 12. However, it must be emphasized that while obvious disease in Old Type means that the beet is usually a complete commercial loss, this is not usually the case in U. S. 12, for the beet usually continues to grow and produces a satisfactory root.

Harvesting of the beets began on October 19 and was completed on October 22. All weights are net, the tare having been deducted. Fig. 9 represents the comparative yield per acre of treated and untreated plots.

No correlation was found between the yield obtained and the spray applied. This was to be expected because the beet leafhoppers were found to have redistributed themselves over the plots after each spray application.

The high yield of U. S. 12 in control plot 1 is explained by two factors. First, it received 200 pounds of phosphate per acre; whereas plots 2 and 3 received 150 pounds per acre, and plots 4 to 14, inclusive, received 100 pounds. Second, it was located so that it received protection from a fence row containing tall weeds and sweet clover and thus had a lower leafhopper population all season than any of the other plots. The low yield in plot 13 is attributed, at least in part, to a very poor stand.

In analyzing the yields it should be mentioned that in general, from the standpoint of weather, soil preparation, stand and leafhopper infestation, conditions were unfavorable for the production of maximum yields of sugar beets. It is, however, very interesting to note the significant difference in yields between U. S. 12 and Old Type beets of 12.60 and 0.64 tons per acre, respectively, a ratio of 19.69 to 1 in favor of U. S. 12. The low yield of Old

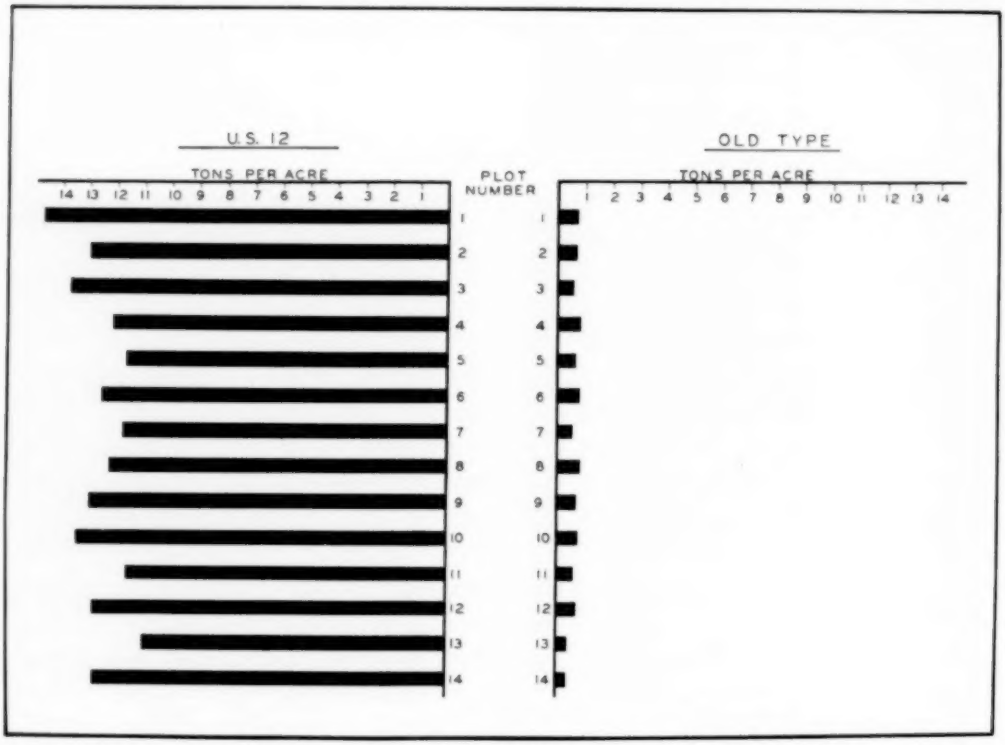

FIG. 9.—Comparative yield per acre of R. and G. Old Type and U. S. 12 strains of beets produced on experimental plots near Buhl, Idaho, 1937. Plots 1 and 14 check; 2, 6 and 10 free nicotine in oil; 3, 7 and 11 derris; 4, 8 and 12 pyrethrum in oil; 5, 9 and 13 nicotine sulfate.

Type beets is indicative of the extremely heavy infestation of leafhoppers in the plots, and consequently demonstrates the ability of U. S. 12 to withstand what might be termed maximum leafhopper infestation together with the other unfavorable factors mentioned and still produce a fairly satisfactory yield.

Campbell (1937) obtained good beet leafhopper control, as stated in the introduction, but did not mention anything about curly top control. He points out that in 1936 he obtained very satisfactory results. Evidently he based his information on kill alone, and not on reduction in curly top infection or increased yields. Satisfactory kill of beet leafhoppers with pyrethrum in oil has been demonstrated, but we have not obtained curly top control, the ultimate object of this work.

FACTORS INFLUENCING CONTROL.—Variations in the percentage of kill in 1936 evidently were caused by many factors, such as per-acre applications, ratio of pyrethrum to oil, temperature, humidity and wind velocity. Since wind velocity and temperature are important physical factors in spraying, especially where oil atomization is used, a study of hourly wind velocity and temperature during the period from May 15 to July 15 over a six-year period was undertaken in an attempt to determine whether there were any hours of the day when the wind velocity was consistently low enough to permit satisfactory spraying. It was found there were two periods in the day when the wind velocity was low (about 5 miles per hour). These were from the hours of 4 to 7 in the morning and from 8 to 12 at night. A study of the temperature for hours having low wind velocity revealed that there was no time when the wind velocity was consistently low enough to permit satisfactory spraying when the temperature was high. Very seldom did the temperature for the above hours reach 70 degrees F., and that was near the end of the period of July 15.

Factors which were not measured may have been the cause of the fluctuation in results that were evident throughout the entire lot of experiments. They are (1) size of plants, (2) weediness of field and (3) cultural condition of the field at time of spraying. Probably other factors were operating which have not been evaluated or recognized. The cultural condition of the field at spraying time appears to be a major factor, when the atomizer is being used. When the surface soil is dry and recently cultivated, the heavy draft of air from the nozzles stirs up a dust cloud and it is evident that dust particles in the air absorb much of the spray material, lessening its effectiveness. In some of the fields where low kills were obtained in 1936 it was thought that heavy weed growth prevented the insecticide from reaching the insects.

Bennett & Wallace (1938) stated that the "beet leafhopper, *Eutettix tenellus* (Bak.), picked up virus from diseased beet plants in a feeding time of 1 minute. The minimum time, however, for an individual leafhopper to pick up virus from a diseased plant and transmit it to a healthy plant was 4 hours. . . . Non-viruliferous leafhoppers placed on a diseased plant acquired sufficient virus in 2 days to give them their maximum ability to infect seedling beets."

This information shows that non-viruliferous beet leafhoppers upon entering the beet fields are capable of picking up curly top from diseased plants and infecting healthy plants within a very short period. Viruliferous leafhoppers are capable of infecting beet plants just as soon as they enter the field. The rapidity with which this insect transmits curly top is a major factor to be considered in curly top control. Another major factor is the duration and magnitude of the spring movement into the beet fields. The exact time required for the spring movement of this insect from the desert to cultivated areas is not known, but we do know that the duration of the period from the first movement until the peak is reached ranges from 12 to 36 days, depending upon the season. The period of migration coincides very well with the seedling stage or the period of susceptibility of the plant. This information shows the length of time the beet plants must be kept free of beet leafhoppers, in order to reduce the curly top infection sufficiently to permit an increase in yield.

SUMMARY.—Of the materials tested, pyrethrum was the only insecticide found to be specific against the beet leafhopper.

The evidence indicates that the 50-to-1 and 40-to-1 ratios of oil to pyrethrum are too large, and best results are obtained at ratios of 25 to 1 and 30 to 1.

In general the percentage kill increased as the pyrethrum content increased. The percentage kill increased as the per-acre application increased from 5 to 6 to 7 to 8 gallons.

Disease counts showed no significant difference between the various treated and untreated plots.

No correlation was found between the yield obtained and the spray applied. This was to be expected because the beet leafhoppers were found to redistribute themselves over the plots following each spray application.

U. S. 12, a resistant variety to curly top, produced a fairly satisfactory yield under a very high degree of leafhopper infestation.

The spring movement of this insect from the desert to the cultivated area extends over a period of from 12 to 36 days.

The period of migration coincides very well with the seedling stage or the period of susceptibility of the plant.—1-3-39.

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The Effect of Thrips Injury on Production in Cotton

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In the season of 1934 an investigation of thrips injury to cotton was undertaken with the object of determining, as closely as possible, the amount of loss due to these insects.

The appearance of thrips-injured cotton plants may be summarized as follows: In the seedling stage the leaves are often tightly curled and later are irregular in shape and ragged in appearance. If the infestation is heavy the undersides of the leaves become silvery. Frequently the terminal bud of the seedling is destroyed, thereby stopping further development of such plants, which die in a short time. When the plant has developed beyond the seedling stage and the terminal bud is injured, growth is greatly retarded until other buds develop. This often results in excessive branching. When one of the branches assumes dominance and grows much more rapidly than the others, a plant may finally approach closely the normal condition, the original injury being only apparent in a slight curve near the base of the stalk. In the first part of this study, such plants are considered normal.

INTENSIVE STUDY OF A FIELD.—An intensive study of severe thrips injury to cotton was made in a field selected in the Brazos River Bottoms in Burleson County. The soil was one of the heaviest types found in the bottom. The variety of cotton was Missdel, a variety widely grown in the locality. The cotton was practically all up by April 10 and was chopped out to a stand the week of May 10–17. The field was of approximately 50 acres. Cotton had been grown in this field the previous year.

Before the cotton was chopped out a survey was made of the extent of thrips injury throughout the field. Starting at a point near the middle of the first row on the south side of the field, examination was made of 100 consecutive plants every 20 rows across the field to the north. No flea hoppers were present, and aphids were very scarce. Thrips injury was greatest at the first eight points, 70.6 per cent of the plants showing injury, while 56.4 per cent of the plants were injured at the last eight points, the average amount of injury being 63.5 per cent. The heavier in-

* The authors' names are in alphabetical order. R. K. Fletcher made the intensive study of thrips injury. J. C. Gaines conducted the survey of thrips injury.

jury near the south side of the field was probably due to two factors: (1) the field adjacent on the south was heavily overgrown with weeds and grass having a large thrips population, and the prevailing wind was from the south. *Frankliniella tritici* (Fitch) was the only thrips found present.

At the time the cotton was chopped none of the injured plants was observed to have died. During the last two weeks in May, after chopping was finished, many of the plants succumbed. The distribution of dead plants was peculiar in that all the plants for several feet along the row had died. There were, of course, many dead plants scattered throughout the field, but the above distribution was noticeable. The leaves of the small dying plants, in addition to the deformed condition ascribed to thrips injury, showed the well-known silvering caused by heavy infestation of thrips. This was not nearly so evident in those plants which lived.

A quarter of an acre was staked off near the center of the field and the cotton picked out on four occasions. Before the picking, the number of thrips-injured plants and the number of normal plants were determined. There was a total of 4,815 or 19,260 plants per acre, of which 64 per cent were injured by thrips. At each picking the number of open bolls on each type of plant was recorded, and also the weight of seed cotton.

From the first the greater productivity of the normal plants was obvious. The data obtained, summarized for the season are as follows: the thrips-injured plants produced a yield of 232 pounds of seed cotton per acre. The normal plants produced a yield of 332 pounds per acre. In other words, the normal plants representing 36 per cent of the total number of plants yielded 58.8 per cent of the seed cotton produced. Upon the same basis as the normal plants, thrips plants if uninjured should have produced 590 pounds of seed cotton per acre. Instead they produced 232 pounds, a loss of 358 pounds of seed cotton per acre.

These results are based upon the assumption that if the field had not been invaded by thrips the plants would all have acted as the average normal plant did in 1934. It does not account for the loss due to plants killed.

Two striking differences were found between thrips-injured plants and normal plants. One of these was the earlier maturing of the bolls on the normal plants. Twenty-one and two-tenths (21.2) per cent of the total number of bolls opening on both types of plants during the season were found on the normal plants at the first picking, while only 8.1 per cent were found on the thrips-injured plants. Also, 72.4 per cent of the open bolls at the first picking were found on the normal plants. These plants produced one pound of seed cotton per 118 bolls, while it took 134 bolls from the thrips injured plants to produce a pound of seed cotton. The data included in the three preceding paragraphs are summarized in table 1.

Table 1.—Comparison of thrips injured plants with normal plants.

	Normal Plants	Thrips-Injured Plants
Per cent	36	64
Number of bolls per pound of seed cotton	118	134
Yield in pounds of seed cotton per acre of injured plants corrected to normal*		590
Actual yield in pounds of seed cotton per acre	332	232
Loss in pounds of seed cotton per acre due to thrips injury		358

* 36:64=332:x.

SURVEY OF A WIDE AREA.—During the latter part of August and September a survey was made on the sandy, light and heavy soils in the Brazos Bottoms on two varieties of cotton (Missdel and Acala)to obtain an estimate of the loss in pounds of seed cotton due to thrips injury. This record was also made on two fields of upland cotton on two varieties, Harper and Startex. Records of the number of plants per acre, number of bolls per plant and per cent of thrips-injured plants were made in 12 bottomland fields and 2 upland fields. By counting the number of plants in 100 feet of row at a number of different points in each field and getting the average width of the rows, the number of plants per acre was calculated.

Bolls were counted on 100 consecutive plants in the row at several points in each field and the number of bolls was recorded for thrips-injured and normal plants.

To obtain the weight of seed cotton per 100 bolls, cotton was picked on consecu-

tive plants in the row, the number of bolls from thrips-injured and normal plants being recorded. These weights were obtained to the nearest gram and calculated to pounds during the first two pickings, or when at least 75 per cent of the bolls were open.

With these data the loss in pounds of seed cotton per acre was estimated. The per cent of plants injured by thrips varied in the 12 fields from 10.67 to 57, an average of 31.9 per cent. The estimated loss in pounds of seed cotton per acre varied in these fields from 43 to 230, an average of 107 pounds. The estimated loss in pounds of seed cotton per acre in the two fields of upland cotton (Harper and Startex) was 83 and 39 pounds, respectively.

Records were kept on 324 normal plants and 192 thrips-injured plants. These records on plant performance were secured to obtain information on the fruiting of the thrips-injured plants as compared to the normal plants. Records on the number of squares, blooms and bolls were made at weekly intervals on plants at 19 points in 4 different fields. Consecutive plants in the row were tagged as thrips-injured or normal the latter part of May at the various points and the data recorded for each plant throughout the season. These data indicate that the thrips-injured plants are from 10 days to 2 weeks later in producing bolls than the normal plants. The 324 normal plants produced an average of 5.73 bolls per plant, while the 192 thrips-injured plants produced an average of only 4.56 bolls per plant.

SUMMARY.—Each of these studies, one of a severely injured field, the other a survey of a wide area, shows the severe loss in seed cotton caused by thrips injury. They also bring out the effects on the plant; that is, the smaller size of the bolls, the number of bolls per plant and the late opening of the bolls.

In a field of cotton severely injured by thrips the loss was calculated to be 358 pounds of seed cotton per acre. Many plants were killed in this field. In 12 bottomland fields the estimated average loss was 107 pounds of seed cotton per acre; in 2 upland fields the loss averaged 61 pounds of seed cotton per acre.—1-5-37.

Notes on the Biology of the Cotton Pruner *Chalcodermus bondari* Marshall

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The cotton pruner, *Chalcodermus bondari* Marshall, was described as a new species in 1927 from specimens sent to the British Museum by Bondar (1927) from Bahia, Brazil. It has been found damaging cotton throughout the state of Pernambuco and as far south as the Chaco region in the Argentine.

The adult weevil is 3 to 4 millimeters long, 1.5 to 2 millimeters wide, and shiny black in color, fig. 1. The following are parts of the insect's description taken from that by Marshall (1927): "Head finely shagreened, with scattered shallow punctures. Prothorax transverse, almost parallel sided from base to beyond the middle and abruptly narrowed in front. Dorsum with 3 transverse furrows in middle which laterally curve forward and become branched; in middle of apical half 6 sometimes irregular and interrupted longitudinal furrows. Elytra broadly ovate with regular rows of foveae, which become smaller behind. Legs with pale recumbent setae; the tibiae bisinuate on the inner edge and without any sharp tooth

FIG. 1.—The adult cotton pruner.

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or serration." Ogloblin (1934) believes that this species may be the same as *C. niger*, which was described by A. Hustache in 1924 from material collected during an expedition to Bolivia.

The adult weevils are active only at night or on dark days, and play dead when disturbed. In the daytime the weevils may be found on the cotton plants in young leaf clusters and in the folds of wilted leaves; often they are found on the ground under the cotton plants under leaves or other debris.

The weevils feed on the leaves, petioles and young green stems of the cotton plants. This pest also commonly attacks several wild Malvaceous plants. The writer has found two wild Malvaceae, one belonging to the genus *Sida*, attacked by the pruner; and also the Euphorbiaceae, *Croton glandulosus*. Bondar (1929) mentions the Malvaceae, "malva branca" and "malva preta" as wild hosts; and according to Ogloblin (1934) Kreibohm de la Vega cites *Hibiscus esculentes*, *Althaea officinalis*, *Malva silvestris* and a species of

FIG. 2.—Cotton stems showing the ring of punctures made by the cotton pruner; also, one egg puncture.

the genus *Sida* as wild hosts. Ogloblin (1934) found the pruner attacking *Althaea* sp. almost exclusively in May (autumn), but equally with cotton in February (summer).

LIFE HISTORY AND HABITS.—The cotton pruner causes the greatest injury to

FIG. 3.—Young cotton plant with apical growth wilted because of the ring injury by the cotton pruner.

cotton plants during the process of egg deposition. The adult female makes a ring of punctures in young green stems and deposits an egg in the plant tissue just above this ring, fig. 2. The females attack in this manner the growing tips, leaf petioles and flower stems of the cotton plants. This injury causes the parts above the ring to wilt and die. Young seedlings are entirely killed by this injury, and frequently all the seedlings in a hill are thus killed. Older plants are severely stunted in their growth, fig. 3. Full grown plants are not severely harmed by these ring girdles, and they may even be of some benefit in preventing too much vegetative growth. However, when the blossom stems are attacked, fig. 4, a direct loss to the cotton crop results. This ringing injury to the cotton plants takes place at night, but the injured parts do not begin to wilt until the following morning, when water evaporation increases. The ring of punctures evidently cuts off the water supply from the parts above it. Usually the wilted parts above the rings remain on the plants and do not fall to the ground. In a few cases when thick stems are ringed the parts above are able to survive the injury and continue growing. In all such cases no larvae are found in any of the attacked stems.

The weevil lays its eggs one in each stem above a ring of punctures and usually

concentrates on one plant at a time until most of its new growth has been injured. It then moves on to the next plant. Observations show that from one to five ovipositions have been made by one adult in a single night.

FIG. 4.—Cotton plant showing two squares wilted because of the ring injury by the cotton pruner.

According to numerous observations by the writer the small transparent egg hatches in approximately three days. The young larva bores up the stem above the ring; and later, when that part of the stem is hollowed out, usually bores down a short distance below the ring. When full grown, in 12 to 18 days, the small cream-colored larva bores a hole to the outside below the ring and drops to the ground. The larva immediately burrows into the ground to a depth of about 5 to 10 centimeters. It remains as a larva in its earthen cell about four to five days and then transforms to the pupal stage in which it remains six to seven days. After pupation the adult remains in the soil about five days, and then emerges as an active adult. The total life cycle of the pest from egg to active adult takes from 30 to 38 days under normal conditions. Bondar (1927) reports the life cycle to be a little less than two months, of which about one and one-half months is spent in the soil. Ogloblin (1934) states that the life cycle in the Argentine takes from 48 to 60 days.

An experiment in which adults were placed with caged plants showed that they do not oviposit during the first week of their active life, although they feed freely. Adults approximately three weeks old when placed with caged plants began ovipositing in four days. This indicates that it takes about three weeks before adults are capable of ovipositing. Ogloblin (1934) states that this weevil has an imaginal diapause, but he does not know its length. The fact that injury appeared daily from February 26 to April 6, 1936, in a small isolated plot of cotton indicates that adults may have an active egg laying period of over a month. Injury was again observed in this plot on May 5, 1936, after a lapse of about a month. From the studies of the life history of this pest it should take about 54 days for injury from a new generation to appear. Since some infested stems were left on the plants early in March, injury from the second generation could be expected early in May. Actually, injury was first observed again on May 5, and this substantiates the observations made on the life history of the cotton pruner.

Whether the cotton pruner goes into aestivation during at least part of the dry season, or whether it reproduces continuously on suitable wild host plants has not been definitely determined. Injury to cotton by the pruner was observed by the writer far into the dry season (December) and was not observed again until shortly after the rainy season began (March). Several attempts at various times were made to see if the adults could be induced to aestivate, but in every case they soon died in a dry environment unless fed. It has been observed that under dry conditions the larvae have a much longer larval period, and may not leave the stems. In one case three stems in which eggs were deposited March 14 were brought into the laboratory April 4 and placed over dry soil. The stems still had the active larvae in them on April 28, 44 days after the eggs were laid. It appears, therefore, that this pest may undergo a larval diapause in the dry season in the cotton stems; or else it may continue reproducing in suitable wild host plants.

PARASITES.—Several parasites have been recorded for the cotton pruner. Bondar reared the Braconid, *Urosygalphus chalcodermi*, described as a new species by Wilkinson (1930), from the larvae of the cotton pruner. Ogloblin (1934) found two Chalcid species, one belonging to the sub-

family Pteromalinae and the other to the subfamily Eurytomidae, *Eurytoma* sp., parasitizing externally the larvae of the pruner. The writer has reared a Braconid, which was identified by C. F. W. Muesebeck of the U. S. National Museum as *Urosygalphus* n. sp. (two females), from the larvae of the cotton pruner. Dr. Muesebeck states in a letter: "This is obviously close to *chalcodermi* Wilk. which was described from a single male, but even after allowing for possible sexual dimorphism it does not seem to me that the present species can be that species." The writer has also reared an unidentified Chalcid parasite from this pest.

CONTROL MEASURES.—Toxicity tests in the laboratory with lead arsenate and Paris green at the rate of 5 grams per liter of water showed that lead arsenate is not an effective poison for the adults, and that Paris green is nearly 100 per cent effective in 24 hours.

Spraying or dusting young cotton plants with Paris green or any equally effective insecticide for the control of the cotton pruner alone is too expensive a proposition for most farmers. However, when injury also occurs from cutworms, the cotton leaf worm *Alabama argillacea* (Hbn.), and the cotton borer, *Gasterocercodes* var. of *brasiliensis* Hambl., the use of an insecticide may be practicable on large plantations, provided the proper equipment and methods are used.

The most applicable methods that can be recommended for control are cultural in nature and overlap the control methods recommended for two other major pests of cotton, the pink boll worm and the cotton borer. Control practices should be started long before the planting season begins, early in the dry season after the cotton crop is harvested. They should consistof destroying all cotton plants, plowing up the fields and leaving them fallow, and cutting down and burning all bushes and weeds within the immediate vicinity of the fields. Care should be taken to keep down all volunteer cotton and wild growth in and around the fields during the dry season. Tree cotton in the interior may be protected by clean culture practices.—1-19-38.

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Occurrence and Responses of a Partial Second Generation of the European Corn Borer in the Lake States

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Early in the investigations of the European corn borer, *Pyrausta nubilalis* (Hbn.), in the Lake States, according to Caffrey & Worthley (1927), it was evident that the insect in this part of the infested territory was producing only a single generation annually, although later a very small partial second generation was noticeable in certain seasons. In more recent years, however, and particularly in 1936 and 1937, it became apparent that midsummer pupation of the corn borer in sections of Ohio, Michigan and Indiana had increased in frequency and, in some localities, had reached measurable proportions. Interest was immediately aroused as to the possible extent of this phenomenon, its underlying causes and the character of the second generation material in an environment hitherto considered adapted to the development of only a single generation of the pest annually.

The present discussion does not attempt a complete and comprehensive answer to all or any of the important ques-

* Grateful acknowledgment is offered W. A. Baker, in charge of European corn borer research, and K. D. Arbuthnot, a fellow member of the staff, for their suggestions and assistance in these studies.

tions raised in connection with the subject, but aims rather to present the available data on the occurrence of a partial second generation of the corn borer in the states mentioned and to point out some of

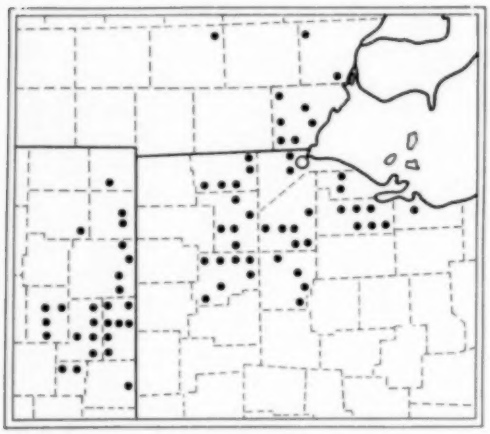

FIG. 1.—Map with black dots showing the approximate points in Michigan, Ohio and Indiana where evidence of a second generation of the European corn borer was recorded in 1936 or 1937. The location of Toledo, Ohio, is indicated by a large clear circle.

the differences in the responses, observed both in the field and in the laboratory, between individuals from the group exhibiting two generations annually and those with only one generation as they occurred near Toledo, Ohio. The experiments here reported have been of a general biological nature, and no attempt has been made to investigate the genetics of the insect.

OCCURRENCE.—Data on the extent of occurrence and the relative abundance of a partial second generation of the corn borer in the Lake States in recent years are confined largely to observations incidental to the field surveys made each fall. The evidence has been either empty pupal cases or unusually small and immature larvae found during dissections of corn plants from about August 15 to September 15. On the basis of such information, the various points of record of second generation occurrence in 1936 and 1937 are shown in fig. 1. As the occurrence of the corn borer in host plants other than corn in this region has been negligible, no attention, in this discussion, is given to plants other than corn.

Ficht (1936) stated that a partial second generation of the corn borer occurred in Indiana in 1934 and 1935, and the Bureau of Entomology and Plant Quarantine of the U. S. Department of Agriculture, in cooperation with the Indiana Department of Conservation, procured data during surveys of abundance, in the falls of 1936 and 1937, to indicate that in these years also a considerable number of individuals in northeastern Indiana belonged to a second generation. A few empty pupal cases were found in growing corn in Indiana in both 1936 and 1937. In addition, 19, or 5.7 per cent, of 335 corn borer larvae observed in the field in Indiana from August 24 to September 19, 1936, were immature, and 112, or 28.1 per cent, of 398 individuals encountered in the same district from August 23 to September 17, 1937, were also immature. It is unlikely that these small larvae were late single generation individuals and very probable that they represented a partial second generation.

The presence of a partial second generation of the borer in Ohio and Michigan became of particular interest in 1936, when an appreciable amount of midsummer pupation appeared in early market sweet corn grown in a truck farming district west of Toledo, Ohio; and it was determined that a second generation of larvae subsequently became established in fields of late corn. Again, in 1937, a partial second generation of the borer developed in the same district. Midsummer pupation in 25 fields of early sweet corn near Toledo in 1937 averaged 8.7 per cent and represented a significant increase from the average of 6.2 per cent found in 1936. In 1937 pupation was found in all but 1 of the 25 fields studied, ranging from 2.8 to 17.6 per cent; in 1936 it occurred in all except 2 of 25 fields, with a minimum of 1.3 and a maximum of 24 per cent. In 1934 and 1935, during similar surveys in early sweet corn near Toledo, pupation was negligible; less than a half dozen pupae were found in either of the two years.

PUPATION.—Limited data indicate that spring pupation of the 1936 second generation larvae in the field in 1937 near Toledo, Ohio, was somewhat earlier than that of the 1936 single generation larvae. On June 8, in caged cornstalks, 20 per cent of 25 second generation individuals had pupated as compared to 12 per cent of 50 single generation larvae; and on June 11, in field debris, 70.1 per cent of 107 second generation individuals had

pupated, in contrast to 30 per cent of 50 single generation larvae observed June 15.

Midsummer pupation of the corn borer in early sweet corn near Toledo in 1936 and 1937 occurred late in July and early in August, starting in the third week of July in both years. In 1937 the first pupa was found on July 20. It should be noted also that near Toledo there is a close relationship between the midsummer pupation of the corn borer and the presence of early sweet corn. In this relationship the seasonal earliness of progeny of the previous year's second generation may be involved.

MOTH EMERGENCE.—Data are presented in table 1 which indicate that moth emergence in the spring of 1937 from overwintered individuals of the corn borer near Toledo, Ohio, was more advanced in the second generation than in single generation material of 1936. Second and single generation corn borer larvae that had overwintered in exposed cornstalks were placed in separate cages on May 25, 1937, and June 1, 1937, respectively, and frequent observations were made of the number of moths that emerged. As an example of the difference in spring emergence of the two groups, it may be noted that 64.2 per cent of the moths from the overwintered second generation larvae emerged by June 30 whereas it was almost a week later, July 6, before approximately the same proportion (65.4 per cent) of the single generation moths appeared.

In the same section in 1936, emergence of moths capable of producing second generation borers was noted in the field on July 29, and over 50 per cent emergence was recorded in field counts on August 4 and 5. In 1937 emergence seemed to be a little later, with slightly over 20 per cent of the moths out by August 5 and 100 per cent by August 24.

Table 1.—Accumulated percentage of moth emergence in 1937 from overwintered 1936 second generation and 1936 single generation corn borers, near Toledo, Ohio.

DATE	SECOND GENERATION	SINGLE GENERATION	DATE	SECOND GENERATION	SINGLE GENERATION
June 19	6.0	1.1	June 30	64.2	18.2
21	17.6	1.3	July 3	80.6	35.5
22	22.3	2.0	6	92.7	65.4
23	31.4	2.4	7	98.3	78.7
24	34.9	3.5	8	100.0	89.0
25	40.5	5.4	10	—	95.8
26	51.7	7.9	14	—	100.0

OVIPOSITION.—Oviposition of the corn borer in northern Ohio, starting usually late in June, normally reaches its peak during the first half of July. There has been no way, however, of separating in the field the eggs deposited by moths descended from the previous year's second generation from those of the more abundant single generation moths. On the basis of the pupation and emergence data just presented, it is assumed that the earlier eggs are deposited by moths that have exhibited a two generation tendency, and some weight is added to the assumption by the fact that a higher proportion of pupation was obtained in the laboratory from rearings of early deposited eggs than of later deposited eggs from the field, the percentage of pupation in this case being considered an index of the prevalence of moths possessing active two generation characters. When handled under the same controlled food and developmental conditions as the material in Experiment 2 (discussed later), pupation was highest (56.8 per cent) at the end of 40 days in larvae reared from eggs collected in the field as early as June 23, 1937; it was 20.4 and 27 per cent in larvae from eggs collected in the field on July 9 and 12, respectively; and lowest (10 per cent) in the progeny of two collections of eggs made July 17.

The first eggs of the second generation in 1936 were found in the field on August 6, and in 1937 on August 4, in the vicinity of Toledo. In the latter year eggs were also recorded on late field corn and on sweet corn on August 24, and it is probable that the deposition of second generation eggs normally occurs throughout August in this section. Ficht (1936) reported that the moths in Indiana, in 1934 and 1935, emerged during August and laid their eggs on very late corn.

Table 2.—Comparison of rate of pupation among 1936 single generation and 1936 two generation corn borer larvae from Toledo, Ohio, at 80 degrees F. and 70+ per cent relative humidity (Experiment 1).

Lot	Dates of Collection	Dates Placed in Incubator	Number of Individuals		Accumulated Per Cent Pupation at End of Given Number of Days in Incubator											
					10		20		30		40		50		60		100	
			Single Generation	Two Generation	One Gen.	Two Gen.	One Gen.	Two Gen.	One Gen.	Two Gen.	One Gen.	Two Gen.	One Gen.	Two Gen.	One Gen.	Two Gen.	One Gen.	Two Gen.
1	Nov. 2–10, 1936	Nov. 7–17, 1936	424	223	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.9	12.8	4.0	46.0	27.2	87.1	74.6
2	Nov. 9, 1936	March 1, 1937	154	189	0.0	0.0	0.0	0.0	4.0	18.5	48.9	82.6	75.6	98.0	88.6	99.0	—	—
3	March 19 to April 9, 1937	March 27 to April 12, 1937	238	302	0.0	0.0	1.2	7.3	25.6	69.6	73.1	92.7	94.1	99.0	—	—	—	—
4	May 20 to June 1, 1937	May 24 to June 2, 1937	174	159	9.8	17.6	60.9	76.2	91.9	95.6	95.4	96.8	—	—	—	—	—	—

Based on field counts of 95 egg masses in 1936, and on 38 in 1937, the average numbers of eggs per mass in the second generation at Toledo were 21.7 and 20.3 for the two years, respectively. These figures are in contrast to the smaller average of 15.4 eggs per mass, determined from much larger samples, for the first generation in both 1936 and 1937.

EXPERIMENT 1.—In laboratory studies concerned with some of the responses of the second generation of the European corn borer in Ohio, first consideration was given to an experiment to compare the rate of pupation of single with that of two generation corn borer larvae produced in the field in 1936 near Toledo, Ohio, when material of both groups was supplied contact moisture and exposed to a constant temperature of 80 degrees F. and a relative humidity above 70 per cent. The larvae used were collected in the fall of 1936 and in the spring of 1937. The single generation borers were taken from fields of early sweet corn known to be infested by one generation in 1936 and presumably free from the attack of a second generation that year. The two generation larvae were taken from a field of late popcorn which, so far as could be determined, was populated in 1936 only by individuals of a second generation. The data from this experiment are summarized in table 2. In the table, lots 1 and 2 represent the rearing of one larval collection of each form of corn borer, lot 3 the average of four collections of each and lot 4 the average of two collections of each.

When both single and second generation larvae, collected early in November, 1936, were placed immediately under conditions suitable for development, only a little pupation occurred prior to a lapse of 40 days, and the single generation borers pupated at a more rapid rate than the second generation larvae, as shown by the data for the collections in lot 1 of table 2. Possibly the slower physiological reaction of the second generation borer was associated with the shorter life, or exposure of the larvae in the field, as compared to the longer period available to the single generation larvae prior to treatment.

However, when 1936 single generation and 1936 two generation larvae, collected in the spring of 1937, or brought in from the field in the previous November and overwintered in cold storage, were placed

in developmental conditions, pupation in both groups started much sooner and was more accelerated among the two generation than among the single generation individuals. It is evident that, after a longer period of diapause, the two generation larvae responded more quickly to the physiological urge to pupate than did the single generation larvae.

EXPERIMENT 2.—In another experiment rearings were made in the summer of 1937 from eggs deposited by moths from 1936 second generation and 1936 single generation corn borer pupae, the larvae of which had overwintered in the field near Toledo. For each of 10 lots, approximately 150 eggs were placed on food in a closed tray and the resulting larvae were given a diet of cut green beans for 10 days followed by peas in the pod for 15 days. Larvae which had not pupated at the end of a 25-day period were isolated on green peas in glass vials, and observation continued on their development. Throughout the experiment the material was kept at a constant temperature of 80 degrees F. and a relative humidity ranging from 70 to 90 per cent. The data obtained on pupation at the end of 40 days in five lots of single generation and five lots of two generation progeny are presented in table 3.

From the results of this experiment it is concluded that there was a real difference between the physiological reactions of progeny of the 1936 single generation and the 1936 two generation larvae of the corn borer in Ohio. Even it is assumed that there was some mixture of the two forms used in the test—a possibility in field collected material—such contamination as might have occurred could not invalidate the marked differences found between the two groups of corn borers. Under the food, temperature and moisture conditions of the experiment the single generation material included an average of 9 per cent of larvae which, on maturity and after 40 days in developmental conditions, did not require a diapause but were stimulated to pupate and so to continue uninterruptedly toward the production of another generation. On the other hand, some of the two generation progeny retained the characteristics of a single generation "strain" of the insect and entered a larval diapause instead of pupating. It was indicated by the data that, at the end of 40 days, 75 per cent of the progeny of the 1936 two generation corn borers possessed a tendency for continuous development, while 25 per cent still required a diapause typical of the single generation

EXPERIMENT 3.—Second generation corn borer larvae, developed from eggs deposited in August under field conditions in the vicinity of Toledo, Ohio, ordinarily approach maturity and enter a diapause to overwinter. To determine the effect of controlled developmental conditions on individuals of this generation, in contrast with their known responses in nature, egg masses, undoubtedly of the second generation, were collected in the field on August 24, 1937, and placed on food in four lots of trays. At the same time four other lots of trays were started with eggs of a known second generation, either deposited in the incubator by moths emerging from pupae collected in the field August 5–13 or transforming in the incubator from mature larvae collected on the same dates. A third group of four lots of trays contained progeny of the 1936 single generation borer from the same source as the material used in Experiment 2; it was considered impossible at that time of year to overcome the diapause tendency of 1937 single generation larvae. All three groups were handled in the same manner as the material in Experiment 2. The results are summarized in table 4.

Table 3.—Pupation among progeny of 1936 two generation and 1936 single generation corn borer, at Toledo, Ohio, reared in controlled developmental conditions, at end of 40 days at 80 degrees F. and 70+ per cent relative humidity, June–August, 1937 (Experiment 2).

LOT	TWO GENERATION		SINGLE GENERATION	
	Number of Individuals	Per Cent Pupation	Number of Individuals	Per Cent Pupation
1	32	59.4	20	5.0
2	37	67.6	64	0.0
3	51	78.4	71	1.4
4	54	81.5	56	26.8
5	36	83.3	56	12.5
Average	—	75.2	—	9.0

At the end of 40 days in the incubator, pupation reached an average of 79.3 per cent among the larvae from second generation, field collected eggs, and an average of 95.2 per cent among those from second

generation eggs produced in the laboratory, as already explained. An average of only 3.1 per cent of the 1936 single generation larvae pupated under the same experimental conditions. Further discussion of this experiment is given under the subject of the influence of nutrition and environment.

INFLUENCE OF NUTRITION AND ENVIRONMENT.—Experimental data accumulated during the season of 1937 by G. T. Bottger in unpublished studies on the nutritive requirements of the corn borer provide considerable evidence that nutrition can influence the expression of the hereditary characteristics of pupation. Bottger found in testing the effects of a large number of nutrients on the single generation borer at Toledo, Ohio, that the percentage of pupation at the end of a given period varied with different foods and was not necessarily correlated with the growth metabolism and consequent survival of the larvae. He obtained as high an average as 38.6 per cent pupation at the end of 40 days in progeny of 1936 single generation larvae reared on sweet corn kernels, while pupation among similar larvae given other foods was much lower. This result obtained in the laboratory may be directly reflected in the behavior of larvae occurring in the field near Toledo, where the greater portion of midsummer pupation is found in early sweet corn and relatively little in nearby field corn. Possibly the nutrients in sweet corn are of a character to induce pupation of the corn borer more readily than those in field corn. The subject merits further study.

EXPERIMENT 4.—The writer conducted one experiment, the data from which offer possible support for the importance of nutrition in relation to the number of generations of the corn borer. A small section of a field of yellow dent corn was covered by a six-mesh wire cage, approximately 40 feet long, 20 feet wide and 9 feet high. The cage was installed June 17, 1937, when the corn was about 2 feet tall, and remained in place throughout the experiment, for the purpose of preventing any deposition of eggs on the plants by corn borer moths from outside sources. The corn within the cage was divided into eight plots of 25 plants each and treated according to the random block method. Four of the plots were infested by hand with eggs from moths of the 1936 single generation and four with eggs from moths of the 1936 second generation, the sources of both being the same as those utilized in Experiment 2. Approximately 100 eggs were placed on each of 10 plants in one plot of each group on July 6, 8, 10 and 12, and the plants dissected 40 days from these respective dates.

Larval survival in the experiment was low, averaging 4.6 and 4.1 per cent in the single generation and two generation plots, respectively. Only one empty pupal case, representing 0.6 per cent pupation, was found among 169 individuals from the two generation larvae, and no pupation was obtained from 182 individuals of the single generation infestation. None of the larvae from either group pupated later after an exposure of 40 additional days to a constant temperature of 80 degrees F. and a relative humidity above 70 per cent. As previously stated, under the laboratory conditions of Experiment 2 an average pupation of 75 per cent in the second generation and 9 per cent in the single generation material was obtained. Of course, it is not certain that nutrition was the primary influence inhibiting pupation in the field experiment; temperature and other factors may have been more important. The question naturally arises, however, as to the probable results if sweet corn instead of field corn had been used in the cage.

It is interesting to note that when both immature and mature second generation larvae (mostly in the third to fifth instar) were collected near Toledo on September 15 and 23, 1937, and isolated on food in the incubator, not a single individual had pupated by the middle of November, indicating that, prior to collection, the influence or influences inducing diapause had acted upon the physiology of the borer to suppress for a more or less prolonged period the capacity to pupate. In view of the results of Experiment 3, wherein a pupation of 79.3 per cent was obtained among larvae reared in the incubator from eggs of the same source as those of the above mentioned larvae, but collected in the field on August 24, it would appear that the diapause of the second generation in the field near Toledo is due largely to more or less immediate influences of the environment. It would be of value to know definitely what factor or

factors operate to produce a suspension of metabolism of the second generation borer in the fall of the year and at what point in the insect's development this physiological habit becomes fixed.

In Experiment 3, although a high pupation was obtained among the larvae reared from eggs of the 1937 second generation of the borer, there was a difference of 16 per cent between the proportion of pupation in the material reared from field collected eggs and that from eggs deposited in the laboratory. In the latter case the field collected, mature larvae or pupae, or both, from which the parent moths were procured, experienced for a varying period of time the effect of developmental conditions in the laboratory. It may be that the controlled temperature or moisture, or their combination, acted on the physiological constitution of the borer in a late stage to promote pupation to a greater extent than occurred among progeny of individuals that had been affected throughout their larval and pupal life in nature by the direct or indirect influences of seasonal weather fluctuations.

Table 4.—Pupation of 1937 second generation corn borers in comparison with progeny from 1936 single generation material, from Toledo, Ohio, reared in controlled developmental conditions, at end of a 40-day period at 80 degrees F. and 70+ per cent relative humidity, August–October, 1937 (Experiment 3).

Lot	Second Generation				Single Generation	
	From Eggs Deposited by Moths in Field and Collected Aug. 24, 1937		From Eggs Deposited in Laboratory by Moths From Larvae and Pupae Collected in Field Aug. 5–13, 1937		From Eggs Deposited in Laboratory by Moths From 1936 Single Generation Larvae Retained in Cold Storage	
	Number of Individuals	Per Cent Pupation	Number of Individuals	Per Cent Pupation	Number of Individuals	Per Cent Pupation
1	86	75.6	80	96.3	81	3.7
2	76	76.3	12	91.7	78	1.3
3	63	76.2	41	95.1	50	8.0
4	75	89.3	54	94.4	53	0.0
Average	—	79.3	—	95.2	—	3.1

SUMMARY AND CONCLUSIONS.—In southeastern Michigan, northwestern Ohio and northeastern Indiana there apparently has been an increase in recent years in the proportion of the European corn borer producing two generations annually. This was particularly noticeable in Indiana and in a localized early sweet corn section just west of Toledo, Ohio.

In the 10 counties of northeastern Indiana surveyed in the fall of 1937, 28 per cent of the corn borer larvae observed were sufficiently immature to indicate that they belonged to a second generation, and as high as 8.7 per cent of the larvae in early sweet corn surveyed in the vicinity of Toledo in the summer of the same year pupated late in July and early in August and produced moths which deposited their eggs during August.

Midsummer pupation of the corn borer near Toledo in 1936 and 1937 was more closely associated with early sweet corn than with field corn, and there may be a direct relationship between the nutrients contained in sweet corn and the earlier pupation of the borer.

Data from controlled experiments in the laboratory offer evidence that the second generation corn borer, as it occurs in the field near Toledo, differs from the single generation in its responses to certain controlled developmental conditions, and that these differences persist from one generation to another. There are indications that the variation in response between the two forms also occurs in nature and is expressed in one way by a seasonal development that is earlier for the first generation of the two generation form than for the more common, single generation form.

Information at present is insufficient to explain satisfactorily the inclination of certain second generation larvae, used in the several experiments discussed, to enter a diapause instead of pupating with the majority of their fellows. Perhaps these non-pupating individuals represent a pure

single generation line capable of resisting such immediate influences as environment and nutrition. On the other hand, it may be that their resistance is apparent rather than real and due only to the lack of the proper stimulus to activate a hereditary tendency.

Environmental and nutritional factors appear to influence the expression of hereditary characters both in the single and two generation forms of the borer, but little is known concerning their relative importance and effect in the inhibition or promotion of pupation, involving the closely related phenomenon of suspended metabolism or diapause, and the consequent result on numbers of generations annually.

The widespread occurrence of a partial second generation in several of the Lake States offers justification for the belief that the so-called "single generation strain" in certain regions is modifying its responses to environment and is now in a state of transition, with a tendency toward an increased proportion of a two generation form, especially in its more southern distribution in Indiana. With any growing abundance of the pest in Indiana, it should be possible to establish the validity of this view.

In the light of present knowledge the recent noticeable occurrence of a partial second generation of the corn borer in the Lake States is considered to be the result of cumulative climatic influences rather than the more immediate weather effects of any single season in itself. However, a longer period of time must elapse before definite conclusions can be reached regarding the permanency of the reactions of the corn borer now being observed in Michigan, Ohio and Indiana. In the meantime, the complex problem opens up an interesting field of experimental investigation, involving, as it does, a number of implications of economic importance.—4-12-38.

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Time of Fumigation of Aphid Infested Canning Peas and Resistance of the Plants to Subsequent Infestation*

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Even the most susceptible strains of canning peas appear to become more resistant to the pea aphid, *Illinoia pisi* (Kltb.) as they approach maturity. This report deals with an attempt to test, under certain conditions, the extent of this resistance. Data are presented which appear to substantiate the observations.

MATERIALS AND METHODS.—For the purpose of this study, 10 plots of wilt resistant Perfection canning peas, replicated four times and randomized, were planted on July 15, 1937. This variety of peas was chosen because it has been found to be the most susceptible to infestation of a long series of canning pea varieties studied. This date for planting was chosen deliberately to avoid confusion of results which probably would have resulted if the peas had been planted at the usual date for canning peas in Wisconsin. At that time they would have grown when large migrations of pea aphids are in progress. A natural infestation from this source would have modified the effects of the induced infestation reported here.

Each plot comprised three 5-foot rows of peas 8 inches apart and separated from the nearest plantings by 2 feet in each direction. Seeds were spaced about 1½ inches apart in the rows. All of the plots were uniformly infested on July 29 at the rate of one aphid to each three plants. This is equivalent of a severe infestation of aphids on peas of equal height grown during the usual season for canning peas. At that time the peas were about 1½ inches tall.

Once each week, beginning the week

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after the peas were infested, the relative number of aphids on each plot was determined by removing five plants, knocking off the aphids into a metal container and counting them. The number of aphids present on the different plots at the different dates is shown on the graph, fig. 1, as the experimentally determined points.

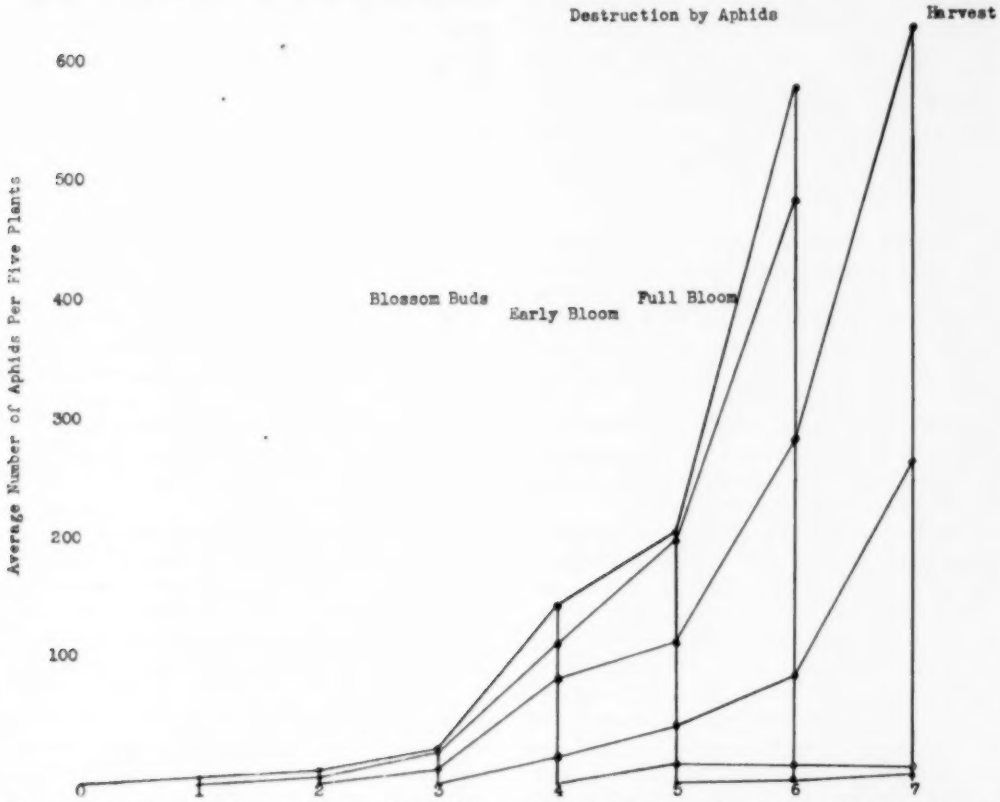

FIG. 1.—Graphic presentation of the relation of stage of plant development and time of fumigation and reinfestation to resistance to the pea aphid. Plot numbers and time of fumigation are given in weeks after initial infestation. Experimentally determined points on vertical line show the number of aphids on five plants at time of fumigation and at weekly periods thereafter. The stage of development of the plants is shown over the appropriate weeks.

During a period beginning one week after the peas were infested and continuing at weekly intervals throughout the experiment, all of the aphids on one plot and its replicates were destroyed by fumigation after a sample for determining the number of aphids had been taken. The plots were fumigated by burning an adequate amount of *Nicofume*, a commercial nicotine fumigant, under cloth and paper covered cages which were $2\frac{1}{2}$ feet high and large enough to inclose one plot. As indicated on the graph, fig. 1, plot 1 was fumigated at the end of the first week, plot 2 at the end of the second week and so on through the fifth week. On the mornings following fumigations, the plots fumigated the day before were reinfested with aphids at the same rate as in the primary infestation.

EXPERIMENTAL RESULTS.—On the graph, fig. 1, the experimentally determined points on the line numbered 0 indicate the average number of aphids found upon five plants from each of the plots still unfumigated at the time, in weeks after initial infestation, shown by the number below the points. Thus, these averages are drawn from a decreasing number of plots in successive weeks. This line presents, therefore, the results from the untreated or check plots. The number of aphids occurring on the fumigated plots each week subsequent to fumigation and reinfestation is indicated by the point on the vertical line at which it is crossed

by the curve of aphid infestation of the plot in question. For instance, the average number of aphids found upon five plants from plot 2 the third week after this plot was fumigated and reinfested is indicated by the point at which the curve of aphid numbers from plot 2 crosses the vertical line over 5 (the third week after 2 was fumigated). This is read as 119. The termination of a curve of aphid numbers on the vertical line over 6 indicates that the plots were destroyed by aphids before counts were made at the seventh week. The termination of the curve of aphid numbers on the vertical line over 7 indicates that the plots were harvested at this date.

The peas came into early bud about the third week after the initial infestation. By the fourth week, they were in early bloom. They were in full bloom the fifth week and ready for harvest by the end of the seventh week after being infested, or the ninth week after being planted. The occurrence of these various phenomena is shown in the figure over the appropriate weeks. This is an unusually short season for this variety of canning peas.

On the untreated plots, many aphids bearing wing pads were on the plants during the third week. Nearly all of the aphids born upon the plants bore wing pads by the end of the fourth week. By the end of the sixth week, nearly all of the aphids in the untreated plots were winged. The fumigation treatment altered the normal succession of winged forms in the treated plots.

DISCUSSION OF RESULTS.—As shown on the graph, the untreated plot was destroyed by aphids before the infestation could be determined the seventh week after the initial infestation. It is probable that the number of aphids reached before the plants were destroyed was materially higher than the last number determined. The method of sampling used did not provide that information. Five plants from plot 1 carried an average of about five aphids when it was fumigated at the end of the first week. The acceleration of aphid reproduction following reinfestation of plot 1 was practically the same as that of the untreated plots with the result that, although it had been fumigated, plot 1 was destroyed by aphids in about the same time as the untreated plot. Plot 2, which had an infestation of about 11 aphids per 5 plants when fumigated at the end of the second week, was about equally susceptible with plots 0 and 1 but, because of its week-later fumigation, could be harvested for canning before it was destroyed. Aphids did not multiply as rapidly upon plot 3 as upon the untreated plot and plots 1 and 2. This suggests that at this stage of growth the peas were already becoming uncongenial hosts. In addition, the postponing of the fumigation for three weeks after initial infestation made it possible for the peas to reach the canning stage before the aphids, after reinfestation, reached the destructive numbers found upon plot 1 and the untreated plot. When fumigated at the end of the fourth week, plot 4 had developed only 155 aphids per 5 plants; but it, like plot 5, which had developed 208 aphids per 5 plants when fumigated by the end of the fifth week, had seemingly become such an uncongenial host to the aphids that the subsequent infestation was practically negligible. The number of aphids on plots 4 and 5 at the time they were fumigated was too small to produce any observable injury to the plants.

CONCLUSIONS.—From these data it may be concluded that a variety of aphid susceptible canning peas became increasingly resistant to a new infestation of aphids as the plants approached maturity. It was obvious that this resistance was associated with some change in the plants which was, in turn, associated with the maturing of the plants and which rendered them uncongenial hosts to the aphid. It is also indicated that, under these unusual growing conditions for canning peas in Wisconsin, if the aphid infestation is completely destroyed about four weeks before the canning date, a subsequent infestation will not destroy the peas before they may be harvested for canning. The similar rate of multiplication of the aphids on plots 0, 1 and 2 after the various fumigation dates suggests that the plants remained relatively attractive to the aphids until the third week after the first infestation. Some time after the third week and before the fifth week, there was, apparently, some change in the plants which rendered them such uncongenial hosts to the aphids that the insects did not multiply thereafter with their usual acceleration. This conclusion is further suggested by the appearance of the

wing-pad-bearing young upon the plants of the untreated plots coincidental with the appearance of blossom buds about the third week. It seems logical to assume that the production of an alate progeny is the aphids' way of escaping uncongenial conditions such as unfavorable hosts. This change, in regard to multiplication and wing formation, in the attitude of the aphids toward the plant appears to be correlated therefore with changes going on in the plant which are associated with blossoming and seed setting.

SUMMARY.—Data are presented which indicate that normally aphid susceptible canning peas become uncongenial hosts to the aphids and cause them to start producing alate forms for migration at about the time that the peas come into blossom. When the aphid population is destroyed at this time, the naturally uncongenial nature of the peas inhibits the normal increase of aphid numbers on subsequent infestation. It is also indicated that, if the aphid infestation upon the peas is destroyed after the fourth week before the usual canning stage, the aphids will not have time to increase to destructive numbers before the peas are harvested for canning.—4-25-38.

Pyrethrum and Oils for Protection Against Salt-Marsh Sand Flies (Culicoides)

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During the past two years experiments have been conducted at Savannah, Ga., and Fort Pierce, Fla., to determine the effectiveness of a mixture of pyrethrum extract and light lubricating oil, when applied to window and door screens, for preventing sand flies (Culicoides) from entering buildings and annoying the persons within. Such a mixture, to be successful, must combine killing or repelling power, lasting quality and ease of application. In the tests conducted, two combinations of oil and pyrethrum proved to have all these properties.

LABORATORY TESTS.—Large numbers of sand flies for experimental uses were collected by sweeping and then were brought to the laboratory and placed in glass jars. Pieces of 18-mesh window screen, treated with various mixtures of a light lubricating oil and commercial pyrethrum extract, were placed over the mouths of the above jars, and other jars were placed so that any flies passing through the screen would be caught in a second jar. The paired jars were placed so that the light would pass through the empty jar and attract the sand flies, which are positively phototropic, thus causing them to attempt to pass through the screen.

The first tests were made with a light lubricating oil having a viscosity of about S. A. E. 5, such as is commonly used for lubricating hydraulic pumps. This oil alone prevented 85 per cent of the sand flies from passing through the screen for a few hours. Tests were then made with a mixture of one part of pyrethrum extract concentrate (20 to 1, *i.e.*, extract of 20 pounds of pyrethrum to 1 gallon of refined kerosene) to 20 parts of the same oil. This kept all the sand flies from passing through a treated screen. It also retained this property for several hours when exposed to conditions similar to actual use in a window. Even after an exposure of 24 hours it prevented 97 per cent of the sand flies from passing through.

Later the following mixtures were tested:

(1)	1 part	pyrethrum extract (20 to 1)
	19 parts	lubricating oil (S. A. E. 10)
(2)	1 part	pyrethrum extract (20 to 1)
	15 parts	lubricating oil (S. A. E. 10)
	4 parts	kerosene
(3)	1 part	pyrethrum extract (20 to 1)
	10 parts	lubricating oil (S. A. E. 10)
	9 parts	kerosene

The first and second mixtures prevented sand flies from passing through

the screens, and the addition of kerosene prevented clogging the meshes. The third mixture had a tendency to run off the screens and was hard to apply.

FIELD TESTS.—During the months of November and December the following mixture was used to paint the screens of a large house located in a heavily wooded area very near a salt marsh at Fort Pierce, Fla.:

22 parts	pyrethrum extract (20 to 1)
321 parts	lubricating oil (S. A. E. 10)
110 parts	kerosene

The result was very encouraging, as sand flies were numerous at that time, and only a few bites were received by persons inside the house after the screens were treated. The entry of a few sand flies was to be expected in view of the close proximity of the building to breeding areas of the insects and the fact that the doors were opened several times during each evening and night.

Other field tests to establish the worth of the mixtures were accomplished by giving samples of several combinations similar to those tried in the laboratory to persons residing near the marshes who had complained of sand fly annoyance. All persons who used the mixtures reported that they received excellent protection even when sand flies were numerous and that the material was effective for 24 hours. One person in an extremely bad sand fly area, who used the mixture of pyrethrum extract and the very light lubricating oil, about S. A. E. 5, reported that an application every 48 hours gave protection.

For applying the oil to the screens either a large brush or a rag was found to be efficient. When a regular household sprayer is used, there is danger of soiling window curtains and shades; also, more material is used than when a brush or rag is employed.

SUMMARY.—As a result of these laboratory and practical tests it has been found that the most effective combinations for excluding sand flies from houses are the following:

1 part	pyrethrum extract concencentrate (20 to 1)
20 parts	lubricating oil (S. A. E. 5)
	or
1 part	pyrethrum extract concentrate (20 to 1)
6 parts	kerosene
12 parts	lubricating oil (S. A. E. 10)

These combinations should be evenly and thoroughly applied to the door and window screens with a brush or rag. The rooms should then be well sprayed with standard pyrethrum extract spray, such as is commonly employed against flies and mosquitoes, to kill sand flies already inside.—5-4-38.

Hydrocyanic Acid Gas in the Vacuum Fumigation of Broom Corn Under Winter Conditions*

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The routine fumigation of broom corn, *Holcus sorghum* L., as part of the quarantine regulations directed against the European corn borer, *Pyrausta nubilalis* (Hbn.), is a matter of some importance, as it is believed that the pest first reached North American from Europe in importations of this commodity (Smith 1920). During some seasons considerable quantities of broom corn are imported into North America. In order to comply with market conditions it is often necessary for some of this material to be brought in during the winter months. The problem has arisen as to whether it is possible to use the standard vacuum fumigation procedure during the cold weather.

PREVIOUS EXPERIENCE.—The question was first taken up by R. I. Smith (1923) who, as the result of an extensive series of experiments, was forced to the conclusion that hydrocyanic acid gas for the fumigation of infested broom corn would not be practicable used under the fumigation methods then in vogue. In this work corn stalks infested with *Pyrausta nubilalis* were placed in the fumigation vault with shipments of imported cotton, according

* Contribution No. 1 from Plant Protection Division, Production Service, Department of Agriculture, Ottawa, Canada.

to Smith "as required by the Federal Horticultural Board. The method is the introduction of hydrocyanic acid gas into cotton while under a 25-inch vacuum. A dosage of 6 ounces of NaCN to 100 cubic feet and a period of two hours is required for all ordinary raw cotton." In this paper Smith did not specifically state whether the vacuum was maintained in the tank after the introduction of the gas, but the regulations of the Federal Horticultural Board (1916 and 1917) called for the dissipation of the vacuum to approximately 5 inches of vacuum after the liberation of the dosage.

The principal observations made by Smith were that corn borer larvae removed from a room where they had been stored at 40 degrees F. to 45 degrees F. and immediately fumigated in a temperature of 65 degrees F. to 70 degrees F. were not killed, but that in some of the experiments a complete mortality of the larvae was obtained with a temperature of 54 degrees F. during fumigation, after the larvae had been subjected to "warmer weather." As the results obtained appeared unpromising, hydrocyanic acid gas was not adopted as a fumigant for importations of broom corn.

In reviewing these findings it is to be noted that warming of the insects prior to fumigation appeared to have more influence on the attainment of 100 per cent mortality than the actual temperatures obtaining during the fumigation period. No statement was given as to the technique employed in counting mortality, but there is a possibility that mortality counts were taken within 24 hours of removal of the stalks from the tank. It is now believed that in fumigation with hydrocyanic acid gas a longer period should be allowed to lapse before the test insects are removed from the commodity, as has been demonstrated by Reed & Livingstone (1938) working with cigarette beetle larvae in baled tobacco.

The method of dissipating the vacuum after the release of the fumigant is not at present advocated in the fumigation of non-perishable goods as a result of the findings of Crumb & Chamberlin (1933) working with the tobacco beetle in cigars and of Lindgren (1936) using the convergent ladybeetle, *Hippodamia convergens* Guer., buried in soil, excelsior and burlap sacks. Apart from the more rapid penetration of the commodity insured by increasing the initial vacuum according to Mackie (1931) Cotton (1932) and Cotton, Wagner & Young (1937) have shown that at high vacuums the resulting oxygen deficiency is a factor tending to make the insects more susceptible to the action of the fumigant.

Problems of Fumigation in Montreal.—After the installation of the vacuum fumigation plant at Montreal the routine fumigation of broom corn was undertaken after a series of experiments had shown that hydrocyanic acid gas in a sustained vacuum was extremely toxic to corn borer larvae in stalks of broom corn under summer conditions. The dosage finally adopted was that of $2\frac{1}{2}$ pounds of hydrocyanic acid gas per 1,000 cubic feet of tank space, introduced after the evacuation of the tank had left an absolute pressure equivalent to between $1\frac{1}{4}$ inches and $1\frac{1}{2}$ inches of mercury. The introduction of this dosage left an absolute pressure of approximately $2\frac{1}{2}$ inches of mercury. At a commodity temperature of 60 degrees F. or over and a tank temperature of around 90 degrees F. this method gave 100 per cent kill of the larvae.

This method of fumigation proved very acceptable to the broom corn importers as it had no deleterious effects on the corn itself and did not affect the ability of the commodity to take the dyes used in coloring the brooms. This is in contrast to the results obtained by treating the corn by the steam sterilization method sometimes used; this latter process appears to make the corn more brittle and also to affect the dyeing qualities.

As the hydrocyanic acid gas method of fumigation described above was satisfactory to the importers we were asked to undertake the fumigation of broom corn during the winter months. As the port of Montreal is closed to shipping each winter from about November 15 to April 15, imported broom corn has to be hauled long distances by rail from the seaboard; it is thus apt to become chilled in transit if carried in box cars. It was with this consideration in mind that the investigation was undertaken to determine if the ordinary routine fumigation could be continued during the winter, provided that some degree of pre-warming were to be

applied to the commodity so as to bring the borers to a state of activity sufficient to render them susceptible to the treatment.

MATERIAL AND METHODS.—As no broom corn is usually grown in the Province of Quebec, early in November, 1936, fully grown larvae of *Pyrausta nubilalis* were collected from infested field corn in an area of severe infestation on Ile Bizard near Montreal. In order to simulate the conditions actually found in in broom corn, stalks were removed from bales of American broom corn and carefully bored from the butt end toward the the head to a depth of about 4 inches. In the tunnel of each stalk were placed three size no. 2 gelatine capsules (three-quarters of an inch long) each containing one corn borer; the capsules were pierced at each end with five pin pricks to aid diffusion; the space behind the last capsule and the base of the stalk was then carefully plugged with about an inch of pith removed from other broom corn stalks with the aid of a cork borer. These stalks containing the larvae were made up into bundles of experimental lots. As a further check on this method, naturally infested, untouched stalks of field corn bound up in screen wire "stockings" were included in the tests and put through the same schedule with the other lots as outlined below.

The bundles of test stalks were first placed in storage at 33 degrees F. and then in cold storage at 10 degrees F. for varying periods of time up to 21 days, as shown in table 1. Lots not fumigated immediately after they had been removed from cold storage were kept in a room at 50 degrees F. to 54 degrees F. for various periods.

The fumigation tests were carried out under ordinary commercial conditions, as the test lots were placed in the fumigation vault while routine fumigation of broom corn was in progress. In this way it was considered that all problems of adsorption would be covered, as in every instance the vault of 1,200 cubic-foot-capacity was loaded to the full with three to three and a half tons of broom corn. At the end of the fumigation period the bundles of test stalks were removed from the tank and returned to the storeroom at 50 degrees F. to 54 degrees F. pending examination.

In every case the usual commercial routine and dosage as described above were followed for the full three-hour period except that in one series the exposure period was shortened to $2\frac{1}{2}$ hours to test the possibility of a reduction in the time of fumigation. As one of these lots failed to yield a complete kill (B-4, table 1) any further thought of curtailing the exposure period was abandoned for the time being.

METHOD OF RECORDING TOXICITY.—Three days after the fumigation test the stalks were removed from the storeroom, where they had been kept at 50 degrees F. to 54 degrees F., and were examined in the laboratory. After the first examination the larvae were carefully replaced in the gelatine capsules and kept for a further 10 to 20 days at 50 degrees F. to 54 degrees F. prior to a further examination of each lot. It is interesting to note that the single live larva recovered in each of lots B-1, B-4 and C-1 was discovered at this second examination. The whole collection was again examined a month after the second count, with no alteration in the results. All the larvae recovered alive were successfully reared through to the adult stage. These facts emphasize the great need for care in recording mortalities from hydrocyanic acid gas, as due allowance for the possibilities of recovery is essential.

EFFECT OF COLD STORAGE ON BORERS.—A control collection of 30 borers was removed from storage after being kept at 10 degrees F. for three weeks. These were removed from the gelatine capsules and placed on the laboratory bench (68 degrees F. to 72 degrees F.) for observation. At first their bodies were flaccid; after they had been pricked with a blunt pencil point the indentation thus formed was slow in filling up. After 20 minutes all the bodies were turgid and several showed signs of life by responding to pricks with weak flexing movements. After an hour all 30 larvae responded with vigorous wriggling movements. After one and a half to two hours they began to walk sluggishly and about two and a half hours after removal from low temperatures the larvae were able to crawl vigorously across the bench.

DISCUSSION OF RESULTS.—In table 1 the results obtained in this work are fully set out. It will be observed that 100 per

Table 1.—Vacuum fumigation for 3 hours of broom corn at a sustained absolute pressure of approximately 2½ inches of mercury after the introduction of 3 pounds of 96 per cent to 98 per cent HCN into a vault of 1,200 cubic feet capacity.

Experiment	Prefumigation Treatment of Test Insects			*Fumigation Temperatures		Test Insects				Remarks
						Corn Borer Larvae, *Pyrausta nubilalis* (Hbn.)				
	Number of Days at 33° F.	Number of Days at 10° F.	Number of Days at 50°–54° F.	Maximum Temperature in Tank	Maximum Commodity Temperature	A	D	T	Mortality Per Cent	
Collection of Larvae in Capsules in Broom Corn Stalks										
A-1	1	3	nil	76	76	0	30	30	100.00	
A-2	1	3	2	82	82	0	31	31	100.00	
A-3	1	3	3	86	88	0	30	30	100.00	
A-4	1	3	7	73	76	0	29	29	100.00	
A-5	1	3	15	74	76	0	31	31	100.00	2½ hrs. exp.
B-1	1	7	nil	83	82	1	31	32	96.00	
B-2	1	7	1	94	94	0	32	32	100.00	
B-3	1	7	3	73	76	0	31	31	100.00	
B-4	1	7	10	74	76	1	29	30	96.00	2½ hrs. exp.
B-5	1	7	14	74	74	0	29	29	100.00	
C-1	1	14	nil	79	77	1	30	31	96.00	
C-2	1	14	1	74	76	0	31	31	100.00	
C-3	1	14	4	74	76	0	30	30	100.00	2½ hrs. exp.
C-4	1	14	7	74	74	0	32	32	100.00	
C-5	1	14	12	74	74	0	32	32	100.00	
D-1	1	21	nil	74	74	0	31	31	100.00	
D-2	1	21	1	86	86	0	31	31	100.00	
E-1	4	nil	nil	76	76	0	30	30	100.00	
E-2	4	nil	2	82	82	0	32	32	100.00	
E-3	4	nil	3	86	88	0	31	31	100.00	
E-4	4	nil	7	73	76	0	33	33	100.00	
E-5	4	nil	15	74	76	0	30	30	100.00	2½ hrs. exp.
F-1	1	3	15	Control	Control	28	0	28	0.00	
F-2	4	nil	15	Control	Control	30	2	32	6.00	
F-3	1	7	5	Control	Control	29	1	30	3.00	
F-4	1	14	69	Control	Control	30	nil	30	0.00	
F-5	1	21	0	Control	Control	29	0	29	0.00	
F-6	Prefumigation Count of Random Test Stalks			Control	Control	70	0	70	0.00	
Collection of Naturally Infested Stalks Done up in Wire "Stockings"										
E-3W	4	nil	3	86	88	0	15	15	100	
A-3W	1	3	3	86	88	0	27	27	100	
B-3W	1	14	0	79	76	0	23	23	100	
F-3W	1	21	nil	74	74	6	19	25	76	
C-3W	1	14	6	Control	Control	24	0	24	0	

* The maximum tank temperature was recorded in the proximity of the test insects. The maximum commodity temperature was obtained by placing a small maximum mercury thermometer within a tunnel bored in a stalk contained in a bundle of test stalks.

cent mortality of the borers was obtained if the stalks were not placed in the fumigation tank immediately after removal from cold storage, except in the case of the exposure period of two and a half hours when a complete kill was not obtained in one lot.

APPLICATION OF RESULTS TO COMMERCIAL PRACTICE.—As the above findings appeared to show that chilled corn borer larvae can be brought to a state of susceptibility to fumigation if only slightly warmed before the vacuum treatment, it was decided that shipments of European broom corn could be handled during the winter months provided the bales were not allowed to become too cold during the last few days before treatment.

Provisional regulations were drawn up to include the following:

(a) Between the dates of April 1 and November 15 freight cars containing broom corn may be moved to Montreal without heat.

(b) Between the dates of November 16 and March 31 cars containing broom corn must be of the refrigerator type and be heated to maintain a temperature of not less than 55 degrees F.

Although complete kills were obtained at vault temperatures as low as 73 degrees F. it was deemed advisable to maintain the vault temperatures between 80 degrees F. and 90 degrees F. during winter fumigations. No corn is placed in the fumigation vault until a temperature of 60 degrees F. or over is found in every part of the bale.

Owing to the fact that storage space sufficient to hold 80 tons of broom corn is available in the Montreal fumigation plant, all the corn handled during the winters 1936–37 and 1937–38 was held on the premises prior to fumigation.

Regular inspections of imported broom corn in the warehouses of importers, made from one to two weeks after fumigation, revealed that the treatment yielded 100 per cent mortality of corn borer larvae in every shipment examined.

SUMMARY.—Larvae of the European corn borer, *Pyrausta nubilalis* (Hbn.), chilled for varying periods up to a maximum of 21 days at a temperature of 10 degrees F. are still susceptible to vacuum fumigation with hydrocyanic acid gas provided they are warmed prior to treatment for a period of 24 hours at a temperature of not less than 50 degrees F.

The commercial treatment of European broom corn based upon these findings calls for a dosage of 2½ pounds of hydrocyanic acid gas per 1,000 cubic feet of tank space acting in a sustained vacuum at an absolute pressure of approximately 2½ inches of mercury for a period of not less than three hours. The commodity temperature required is one of not less than 60 degrees F. in any part of the bales; the vault temperature is maintained at 80 degrees F. to 90 degrees F. with the aid of heating coils.

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THE federal quarantine relating to the pink bollworm of cotton was amended, effective November 17, to add new area, affecting Pinal and Maricopa counties, Ariz., and the Texas counties of Brooks, Jim Wells, Kenedy, Kleberg and Nueces.

THE tomato pinworm quarantine of Oregon was amended on January 6 to eliminate the state of Missouri from territory designated as infested.

THE California quarantine proclamation relating to the peach mosaic disease in other states was extended on December 27 to include additional counties in Colorado, Texas and Utah.

CURRENT revisions of the alfalfa weevil quarantines of Illinois and Wisconsin extend the infested area to include counties not heretofore designated as infested with the weevil.

Hemipterous Insects of Cotton in Arizona: Their Economic Importance and Control

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For years much of the cotton produced in Arizona has been characterized by excessive "spotting" or "staining" of the lint. So pronounced is this that in some of the more important cotton-growing sections an average loss of about $5 per bale is experienced. This is due to the lowering of grade on account of the "off-color" classification, which establishes a lower market value. While this condition has been recognized, the actual causative factors have until recently been unknown. The severe staining has been variously attributed to a number of agencies, among which were local climatic conditions, soil variations and physiological causes in the cotton plants themselves.

Only in recent years has the possibility that insects may be responsible for this type of cotton injury been seriously considered. The reason for this was that comparatively few of the commonly recognized cotton pests occur in the Arizona cotton fields, and those that do occur did not seem to be present in sufficient numbers to account for the quantity and character of damage exhibited. Field observations begun in 1932, however, developed the fact that a number of hemipterous insects were persistently present in those cotton sections exhibiting the most severe staining of cotton lint. Preliminary tests made by caging numbers of these species over growing cotton soon gave evidence that they were capable of inflicting severe damage to the fruit. Once this had been established, the problem was to determine definitely the damage caused by the different species, by isolating them separately on growing cotton plants under large screen cages. These tests have now been conducted each year since 1933, and the several species chiefly responsible for the heavy damage occurring annually in the cotton fields of Arizona have been identified.

Species of Hemipterous Insects Involved.—Fifty-three species of hemipterous insects have been collected from the cotton fields of Arizona and specifically determined by H. G. Johnston. The majority of these species occur in limited numbers, and do not appear to cause appreciable damage to the cotton plants. A number of species are predacious, and by destroying injurious insects are distinctly beneficial. These include members of the Reduviidae, Phymatidae, Nabidae and other predacious families.

About 15 species have been found to feed and breed directly upon the cotton plants and in varying degrees must be classed as definitely injurious to cotton. However, most of the damage is caused by eight species. The more important Hemiptera attacking cotton in Arizona include the following three Pentatomidae: *Euschistus impictiventris* Stål, frequently termed the "brown cotton bug" in Arizona. Repeated cage tests, confirmed by numerous field observations, have shown that this species is probably the most injurious cotton insect occurring in the state. Say's stinkbug, *Chlorochroa sayi* Stål, sometimes called the "green cotton bug," "Say's plant bug" and "the grain bug," is a close second to *Euschistus impictiventris* in the amount of damage inflicted on the cotton crop of Arizona. A smaller pentatomid, *Thyanta custator* (F.), does much less damage than the two first named species. Not only is it less abundant but it appears to vary in numbers, being very numerous one year and comparatively scarce the next. In cage tests it punctured a large number of cotton bolls, and ranks as one of the more injurious hemipterous insects of cotton in the amount of damage caused per insect.

The next most injurious family of Hemiptera on cotton in Arizona and perhaps of equal importance is the Miridae. There are a number of species of this family which in the aggregate cause much damage to the cotton crop. The most important belong to the genus *Lygus*, of which three species occur in Arizona. The predominant species is *L. hesperus* Knight, followed by *L. pratensis oblineatus* (Say) and *L. elisus* Van D. The last species

* The authors were assisted in the field by H. G. Johnston, L. W. Sheets, D. W. Clancy, J. M. Breazeale, W. A. Stevenson and L. D. Christenson.

occurs only in certain sections, while the first two are distributed generally over the state.

Another mirid which in cage experiments has given indications of considerable economic importance is *Creontiades femoralis* Van D. This species does not occur in large numbers, but in every field cage in which it has been isolated the cotton plants have exhibited a curiously deformed, vegetative growth, accompanied by a comparative scarcity of fruiting.

Several species of *Corizus*, of the family Coreidae, are found on cotton, but the writers have not yet determined their potentialities for damaging the crop. While the cage tests have proved that they are capable of inflicting a certain amount of injury, under field conditions they seldom occur in sufficient numbers to attract attention.

The cotton flea hopper, *Psallus seriatus* (Reut.), occurs generally over Arizona and can usually be found in small numbers in all cotton fields. This well known pest seems to pay little attention to cotton, however, when sufficient native host plants are available, and it is of minor importance in Arizona.

Dysdercus mimulus Hussey, a pyrrhocorid, commonly referred to as a cotton stainer, also occurs generally over the state. A number of cage tests with this species indicates that its importance has been greatly overrated. While it is capable of making minute punctures in cotton bolls, it seldom causes conspicuous damage. The staining of lint following its work is not nearly so severe as the staining following the attacks of the pentatomids.

The insects enumerated above include the most injurious Hemiptera occurring in Arizona cotton fields. Additional species occur which are economically important in other sections, but for some reason they do not become abundant in Arizona cotton fields. *Chlorochroa ligata* (Say) is a typical example. This large pentatomid is recognized as one of the most injurious hemipterous cotton pests in the Big Bend section of Texas and in the Laguna district of Mexico; in Arizona cotton fields, however, weeks may elapse between the dates of collection of individual specimens.

CHARACTER OF INJURY.—The injury caused by hemipterous insects upon the cotton plant varies with the season of the year, the species concerned and the stage of development of the cotton plants. Many terminal buds are injured as the result of the work of *Lygus* spp., *Creontiades femoralis*, *Psallus seriatus* and other mirids. Young squares and small bolls are blasted and shed in great numbers, mainly as the result of attacks of *Lygus* spp. and *C. femoralis*. The most conspicuous injury, however, and the damage most keenly realized by cotton growers, consists of the puncturing of the bolls, followed by the development of severe lint staining by introduced pathogenic organisms. This is chiefly the work of the pentatomids, exemplified in Arizona by species of *Euschistus*, *Chlorochroa* and *Thyanta*, assisted to a certain extent by *Lygus* spp., *C. femoralis* and other mirids, and the pyrrhocorid *Dysdercus mimulus*.

Punctured bolls not thrown off by the plant may exhibit injury varying in degree from a slight stain, involving the fiber of one seed in one lock of the matured boll, to what is termed an "unpickable" boll, or a boll in which every seed in every lock has been punctured, resulting in a mummified, prematurely half-opened boll, in which the lint in every lock is impacted, stained, short, weak and of little marketable value, and the seed so damaged as to be of no value, fig. 1. In heavily infested areas enormous numbers of these "unpickable" bolls remain on the plants after the crop has been picked. The lint from the damaged but pickable bolls becomes mixed with the undamaged lint and thus lowers the grade and value of the harvested crop by several dollars a bale. The seeds are injured during early development and fail to mature, thus reducing their value for planting or crushing.

A secondary source of trouble is in the dissatisfaction resulting among the cotton pickers in fields which have been heavily "stung" (local term) by hemipterous insects. This aspect sometimes assumes serious proportions, and results in much migration of pickers from camp to camp in their efforts to locate "clean" cotton fields. The cause of the trouble is the "sticking" or adhering of the lint to the proliferations within the punctured bolls, augmented by the tendency of badly punctured bolls to open only partially.

FIG. 1.—Types of pentatomid injury to cotton bolls. The two upper bolls are "unpickable" while the two lower bolls are partially injured and badly stained.

Several "pulls" are required to pick out cleanly a heavily punctured boll, while in a clean unpunctured boll the lint can usually be picked out in a single motion. In fields containing a large percentage of punctured bolls, the amount of cotton a picker can gather is frequently cut down to one-half or less, reducing the pay of the picker to the same extent.

EXTENT OF DAMAGE TO COTTON.—No definite figures are available to indicate the extent of the loss inflicted upon the Arizona cotton crop through the blasting and shedding of leaf buds, squares and young bolls. The probability, however, is that these losses are somewhat less serious than would be expected on account of the well-known tendency of the cotton plant to put on extra fruit after the early fruit is removed or destroyed by any means.

In the case of losses resulting from boll puncturing, there is considerable evidence indicating that the total figure is surprisingly large. For the four years, 1934 to 1937 inclusive, an intensive survey of the cotton crop has been made each fall in all of the main cotton growing sections of Arizona. Representative cotton fields were selected in all these areas and equal numbers of bolls were collected from five points in each field. The thousands of bolls collected each year were brought into the laboratory and examined individually, both externally and internally. A summary of the results of the annual surveys is given in table 1.

Table 1.—Summary of cotton bolls punctured by hemipterous insects in representative fields in Arizona, 1934–1937.

YEAR	NUMBER OF BOLLS EXAMINED	PER CENT OF BOLLS PUNCTURED
1934	18,398	23.4
1935	30,700	27.2
1936	41,500	24.8
1937	41,200	23.5
4-year total and average	131,798	24.6

The figures in table 1 show that on an average over the state every fourth boll of upland cotton was injured by hemipterous insects. Pima, or long-staple, Egyptian-type cotton, which comprises about 7.5 per cent of the acreage planted to cotton in Arizona, is injured much

less severely than upland cotton. From 1935 to 1937 the puncture bolls averaged only from 2.5 to 7.7 per cent.

The comparative amount of boll injury varies greatly with the locality. Yuma County, in the southwestern corner of the state, has consistently shown the heaviest injury by hemipterous insects, ranging from 40.3 per cent punctured bolls in 1937 to 57.7 per cent in 1934, with a four-year average of 49.7 per cent. Pima County has as consistently shown the least injury, ranging from 5.1 to 12.2 per cent bolls punctured, with a four-year average of 7.9 per cent. The remaining cotton producing counties have always fallen in between these two extremes of infestation. The boll puncturing insects are general feeders, and the proportion of land planted to cotton and other crops such as alfalfa, sugar beets and sorghums, and the abundance of desert vegetation on which they develop and migrate to cotton are important factors influencing the regional variations in damage. The comparative elevations of the principal cotton producing areas of the state may also influence the insect populations in cotton.

CONTROL EXPERIMENTS.—Preliminary control experiments with the different species confined separately and collectively in lantern globes and small field cages indicated that dusting with sulfur or arsenicals would give some control against this group of insects. Many insecticides and combinations of insecticides have been tested in the cages and the most promising ones tried out in the field.

All of the insecticidal tests have been made on upland cotton. In 1933 small field plots were used at Buckeye, Ariz., and four applications of approximately 14 pounds of insecticide per acre per application were made to each plot with a hand dust gun. The sulfur dusted plots gave an increase in yield over the check of 469 pounds of seed cotton per acre; the calcium arsenate, 384 pounds; the lead arsenate, 297 pounds.

In 1934 derris, pyrethrum, sodium fluosilicate, sulfur and lead arsenate were tested in field plots at Buckeye. Six dust applications of approximately 18 pounds per acre per application were made to the respective plots with hand dust guns. The sodium fluosilicate gave an increase in yield of 517 pounds of seed cotton per acre; lead arsenate, 454 pounds, pyrethrum (0.58 per cent total pyrethrins), 328 pounds; sulfur, 189 pounds; and the derris (4 per cent rotenone), 151 pounds. It developed, however, that the soil was better in the sodium fluosilicate plot, and part of the increase in yield from this treatment was evidently due to this factor.

In 1935 derris and pyrethrum diluted with sulfur and mixtures of sulfur and calcium arsenate and sulfur with Paris green were added to the insecticides tested at Buckeye. Nine applications of approximately 10 pounds of each insecticide per acre per application were made in the respective plots. The lead arsenate treated plot gave an increase in yield of 523 pounds of seed cotton per acre; the Paris green and sulfur mixture (1–14), 248 pounds; the sulfur, 206 pounds. The increases from the derris-sulfur and pyrethrum-sulfur mixtures were considerably less, and the sodium fluosilicate treatment gave no increase in yield.

In 1936 a five-row power duster was secured, and ten 5-acre plots were treated at Buckeye. Eight applications of each insecticide were made to the respective plots, but owing partially to unfamiliarity with the power machine only about $5\frac{1}{2}$ pounds of each insecticide per acre per application was used. Because of irregularities in the stand of cotton, caused by the beet armyworm, *Laphygma exigua* (Hbn.), and soil conditions in the plots, the results secured in 1936 were not consistent or satisfactory. The mixture of calcium arsenate and sulfur (1–2) gave an increase in yield of seed cotton per acre of 546 pounds; the mixture of Paris green and sulfur (1–9), 274 pounds; and sulfur, 150 pounds. The arsenicals [calcium arsenate, lead arsenate and a mixture of Paris green and calcium arsenate (1–3)] gave smaller increases in yield and in some cases lower yields than the checks. The increases in yield in 1936 were considerably lower than in previous years and indicated that insufficient dosages were used.

In 1937 the experiments were enlarged to include small plots at Mesa, Ariz., 3-acre plots at Buckeye, and one-third-acre plots at Yuma. The infestation and damage were very light at Mesa, moderate at Buckeye and heavy at Yuma, and

these conditions were reflected in the increases in yields secured. At Mesa five applications were made between July 22 and August 21 at the rate of approximately 16.5 pounds per acre of sulfur and sulfur-arsenical mixtures, and 8.2 pounds of calcium arsenate and lead arsenate. At Buckeye six applications were made from July 13 to August 17 with an average of 13.1 pounds per acre per application of sulfur and the sulfur-arsenical mixtures, and 7.6 pounds per acre per application of the arsenicals. At Yuma, where the insect population was heavy and the growing season long, 12 applications were made from July 2 to September 15 with an average of 24.5 pounds per acre per application of sulfur and the sulfur-arsenical mixtures and 11.5 pounds of lead arsenate. Although the tests at the different localities are not strictly comparable, the results are grouped and presented in table 2.

Table 2.—Increase in yield of seed cotton per acre of dusted plots over checks in tests at Yuma, Buckeye and Mesa, Ariz., 1937.

Insecticide	Yuma		Buckeye		Mesa	
	Pounds	Per Cent	Pounds	Per Cent	Pounds	Per Cent
Calcium arsenate plus sulfur*	2,333	99.9	684	42.5	No test	
Paris green plus sulfur†	2,691	116.8	818	74.4	114	7.1
Sulfur	1,274	55.3	1,078	98.0	178	11.2
Paris green 25%, calcium arsenate 75%	No test		1,118	69.5	58	3.7
Calcium arsenate	No test		818	43.8	43	2.7
Lead arsenate	600	25.7	310	18.5	120	7.6

* Calcium arsenate, 33⅓ per cent, plus sulfur, 66⅔ per cent, was used at Yuma; and calcium arsenate 20 per cent plus sufur, 80 per cent, was used at Buckeye.

† Paris green, 10 per cent plus sulfur, 90 per cent, was used at Yuma; and Paris green, 5 per cent plus sulfur, 95 per cent, was used at Buckeye and Mesa.

In the Mesa experiments, where the infestation was very low, and in the Buckeye experiments, where the infestation was moderate, the largest gains were secured from sulfur, with increases in yield of 178 and 1,078 pounds of seed cotton per acre, or 11.2 per cent and 98 per cent respectively, over the untreated checks. At Yuma, where the infestation was very heavy, the best gains were secured from the mixtures of Paris green and sulfur (1–9), and from calcium arsenate and sulfur (1–2), with increases in yields of 2,691 and 2,333 pounds of seed cotton per acre, or 116.8 per cent and 99.9 per cent respectively. Sulfur gave an increased yield of 1,274 pounds of seed cotton per acre, or 55.3 per cent.

The cage and field tests indicate that the group of hemipterous insects attacking cotton can be controlled to a certain extent and large increases in yields can be secured by dusting cotton with arsenicals, sulfur and mixtures of arsenicals and sulfur. Under some conditions sulfur has given the best results, but where the infestation is heavy the best control of these insects can probably be secured with mixtures of Paris green and sulfur or calcium arsenate and sulfur. Until more information is secured, the widely varying local conditions prevent a more definite recommendation of insecticides, or an exact estimation of the expense involved.

Applications of insecticides should be made at the rate of 15 to 18 pounds per acre. In cases of light insect infestation and damage, five to six applications at weekly intervals should be sufficient, but with heavy infestation, six to nine applications may be required.

Application costs will vary widely according to the acreage treated and to the type of machinery utilized. Where large acreages are involved, commercial airplane dusting or power machine dusting concerns will apply insecticides at designated dosage at an average rate of 50 cents per acre per application. On the basis of 4 cents per pound for dusting sulfur, 8 cents for calcium arsenate, 22 cents for Paris green and 15 cents per 100 pounds for mixing, the mixtures of calcium arsenate and sulfur ($33\frac{1}{3}$ per cent to $66\frac{2}{3}$ per cent) or Paris green and sulfur ($7\frac{1}{2}$ per cent to $92\frac{1}{2}$ per cent) will cost approximately the same, or about $5\frac{1}{2}$ cents per pound. The expense of dusting will range from $1.33 to $1.49 per acre per application, depending upon the amount of insecticides used.

Further work is needed to determine the best proportions of the sulfur-arsenical mixtures, the dosage per acre, and the time and number of applications for the most economical control of this complex group of hemipterous insects on cotton.

SUMMARY.—Fifty-three species of hemipterous insects have been identified from the cotton fields of Arizona. Many of these species are apparently harmless, and a few predacious species are beneficial. Some 15 species, however, feed and breed upon the cotton plants, and cause losses in quality and yield of lint.

The more important injurious hemipterous cotton insects include three species of Pentatomidae, four species of Miridae and one pyrrochorid. Several additional species inflict lesser injuries. The damage consists of (1) the injury to the terminal buds, causing malformation of the cotton plant, (2) shedding of squares and small bolls and (3) puncturing the bolls followed by lint staining from introduced pathogenic organisms. The damage to punctured bolls not shed by the plant varies from slight staining which lowers the grade and value of the lint to complete loss. In heavy infestations many bolls are caused to open prematurely, the lint is mummified, weakened and badly stained, and the seed is made valueless. Picking is more difficult and causes dissatisfaction among the pickers. Annual surveys from 1934 to 1937 show that the average proportion of punctured bolls in upland cotton varies from 8 to 50 per cent in different sections of the state, with an average of 25 per cent for the state over the four-year period. Pima cotton is less severely damaged.

Control tests with various insecticides, extending over a five-year period are reported. Increases in yield were secured from dusting with arsenicals, sulfur, and mixtures of arsenicals and sulfur. Where the infestation is heavy, several applications of mixtures of Paris green and sulfur or calcium arsenate and sulfur, dusted at the rate of 15 to 18 pounds per acre per application, will probably give the best control. In localities where damage is severe the yield has been doubled and the quality of the crop improved by the use of these insecticides.—5-18-38.

Insecticide Tests for the Control of the Bollworm in 1936

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Several reports (Gaines 1937; Moreland 1938; Moreland & Bibby 1931) have been published recently in the JOURNAL OF ECONOMIC ENTOMOLOGY concerning the control of the bollworm, *Heliothis obsoleta* (F.), as progress reports of the cooperative project between the U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine, and the Texas Agricultural Experiment Station. The results of these tests have shown that dusting with calcium arsenate at the rate of about 8 to 9 pounds per acre gave the most effective and economical control of this pest. Additional tests in connection with this project were made by the senior author in 1936, and the analysis and interpretation of the data were made by the junior author. The work was conducted in the Brazos River Bottoms. The purpose of the project was to determine the comparative effectiveness of the following insecticidal dusts: calcium arsenate, calcium arsenate plus 5 per cent Paris green, calcium arsenate plus 10 per cent Paris green, calcium arsenate plus cubé (containing 0.8 per cent rotenone), calcium arsenate plus pyrethrum (containing 0.09 per cent pyrethrins I and II), calcium arsenate plus 50 per cent lime, and calcium arsenate plus 50 per cent sulfur.

ARRANGEMENT OF PLOTS.—The Latin square method of plot arrangement was used in these tests. A number of treatments was made equal to the number of replications and each treatment occurred once in each row and once in each column; otherwise the arrangement was at random. The square used was one containing 64 plots, each 8 rows wide and 50 feet long, each plot being one thirty-second of an acre in area. A buffer of two rows was left untreated between adjoining

* Thanks are due A. B. Beavers, H. T. Vanderford and T. T. Carter for assistance in obtaining the field notes.

Table 1.—The arrangement of plots in the Latin square tests of insecticides for bollworm control and yield at College Station, Tex., 1936.

*B †7.25	D 6.31	C 7.00	F 6.25	H 5.31	A 4.69	G 4.31	E 7.00
D 7.69	B 5.88	E 7.06	G 5.06	C 6.88	F 6.13	A 4.00	H 4.94
E 6.75	G 5.06	H 6.63	A 4.00	B 7.63	C 8.63	D 8.50	F 9.31
G 6.06	H 6.81	B 7.94	C 8.13	D 8.63	E 9.00	F 8.31	A 5.56
C 8.38	E 7.94	F 8.81	B 11.19	A 8.63	D 10.94	H 9.06	G 7.00
H 8.06	A 6.38	D 7.88	E 8.94	F 9.50	G 7.81	B 9.00	C 8.44
A 4.25	F 8.19	G 5.25	D 8.81	E 8.94	H 9.75	C 10.06	B 8.31
F 7.94	C 8.50	A 6.06	H 8.13	G 8.50	B 10.38	E 10.00	D 9.31

* The letters indicate the different treatments.
† The figures listed in each block represent the yield in pounds of seed cotton on one seventy-eighth of an acre.

plots. The arrangement of the plots is shown in table 1.

POISON APPLICATIONS.—The dust applications were made early in the mornings (4:30 to 7 a.m.), with a one-row, fan-type hand gun, while the cotton was wet with dew. Applications were made on August 15, 20 and 26, and September 4. The kind and average amount of dust each plot received are shown in table 3.

INFESTATION.—Records of bollworm infestation or injury were taken, but since these records were not made during the period when the worms were most injurious, they are not considered as a criterion of the effectiveness of the insecticides. A record of the boll weevil infestation, taken on August 24, showed that weevils were puncturing less than 2 per cent of the

Table 2.—Analysis of variance of yield of seed cotton from 64 plots in insecticide tests at College Station, Tex., 1936.

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE
Total	63	190.07	—
Between rows	7	71.81	10.26
Between columns	7	16.03	2.29
Between treatments	7	75.08	10.73
Remainder	42	27.15	.65

Table 3.—The rate of application and mean yield for the eight treatments and the difference between treatments necessary for significance in tests at College Station, Tex., 1936.

TREATMENT	AVERAGE RATE INSECTICIDES WERE APPLIED*		MEAN YIELD PER PLOT	MEAN YIELD PER ACRE
	Mixture	Calcium Arsenate		
D, calcium arsenate+Paris green 90:10	9.00	8.10	8.51	664
B, calcium arsenate		9.00	8.45	659
C, calcium arsenate+Paris green 95:5	9.24	8.79	8.25	644
E, calcium arsenate+cubé (0.8 per cent rotenone)	10.00	8.00	8.20	640
F, calcium arsenate+sulfur 50:50	15.52	7.76	8.06	629
H, calcium arsenate+lime 50:50	14.00	7.00	7.34	573
G, sulfur+pyrethrum (0.09 per cent pyrethrins I and II)	17.00	none	6.13	478
A, check	none	none	5.45	425
Significant Difference†			0.81	63

* Rate of dust applications calculated to acre basis.
† 0.05 level.

squares in all plots. This was not considered as a factor which affected the yields.

YIELD.—The yields in pounds of seed cotton were obtained from each plot on four rows, each row being 41 feet long, or one seventy-eighth of an acre. These records are given in table 1.

RESULTS.—The data on yields were analyzed by the method of analysis of variance. Table 2 shows the variance between treatments and between different rows and columns attributed to the heterogeneity of the soil and distribution of the worms. The remaining variance, denoted by 42 degrees of freedom, provides an unbiased estimate of error in the comparison of the treatments.

The yield records indicate that treatments D, B, C, E and F were equally effective in controlling the worms. Treatment H, calcium arsenate at the rate of 7 pounds per acre, was not so effective as treatment D or B, where 8.1 and 9 pounds of calcium arsenate, respectively, were used. There was no significant difference between treatments F and H, in which sulfur and lime, respectively, were used to dilute the calcium arsenate. Treatments G and A were significantly less effective than any of the other insecticides used.

SUMMARY.—The analysis of the yield in these tests indicates that calcium arsenate, calcium arsenate plus Paris green (5 and 10 per cent), calcium arsenate plus cubé (containing 0.8 per cent retenone), and calcium arsenate plus 50 per cent sulfur were equally effective against the bollworm. All plots received calcium arsenate in the foregoing mixtures at the rate of 7.76 to 9 pounds per acre. When the rate of application of calcium arsenate was reduced to 7 pounds per acre, as in the calcium arsenate plus lime mixture, the yield was likewise reduced. Pyrethrum dust (containing 0.09 per cent pyrethrins I and II) with sulfur as a carrier did not prove effective against these pests.

These results agree with previous reports concerning this problem, namely, that calcium arsenate applied at the rate of from 8 to 9 pounds per acre proved to be the most effective and economical insecticide for the control of the bollworm. —5-18-38.

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Toxicity of Hydrogen Cyanide, Chlorpicrin and Ethylene Oxide to Eggs, Nymphs and Adults of the Bedbug*

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Considerable experimental work has been conducted to determine the action of various fumigants on the different stages of the bedbug, *Cimex lectularius* L., but no experiments have been reported in which the five-hour median lethal concentration has been used as a basis for comparison. It is the purpose of this paper to present experimental results comparing the toxicity of hydrogen cyanide, chlorpicrin and ethylene oxide to eggs, nymphs and adults of the bed-bug.

* Contribution from the Montana State College, Agricultural Experiment Station. Paper No. 111, Journal Series.

EXPERIMENTAL METHOD.—Eggs, nymphs and adults of the bedbug were exposed to varying concentrations of hydrogen cyanide, chlorpicrin and ethylene oxide. The experiments were performed at 25 degrees C. in fumigation chambers as originally designed by Strand (1930) and modified by Lindgren & Shepard (1932). These were Erlenmeyer flasks of approximately 6.4 liters capacity, each fitted with a ground glass stopper into which were sealed two glass tubes equipped with stopcocks.

The eggs used in these tests were two

days old; the nymphs were of the second and third instars; the adults were of various ages. Thirty individuals of each stage were used in every test.

The hydrogen cyanide was prepared by reacting sodium cyanide with sulfuric acid. The resulting gas was condensed and redistilled until it reached the freezing point of pure hydrogen cyanide. The purified hydrogen cyanide was then measured into the fumigating chambers as a gas and its weight was determined by the formula $PV = g/M\ RT$, in which P is atmospheric pressure, V is gas volume, g is weight of gas, M is the molecular weight of the gas, R is the gas constant (82.06 cc. atm./mol. deg.), and T is the temperature in degrees absolute at which the volume of gas is measured. It was found that this method was accurate within 1 per cent when checked by titrating a given volume of gas with silver nitrate according to the method of Scott (1925).

Ethylene oxide was also measured into the flasks as a gas, while the chlorpicrin was introduced as a liquid by means of a micropipette.

The experimental animals remained in contact with the different gases for five hours at 25 degrees C., after which they were placed in glass vials at 27 degrees C. Mortality counts on nymphs and adults were made at the end of 24 and 48 hours, while the counts on the eggs were made at the end of five days. The criterion of death used for the nymphs and adults was total lack of movement. Egg counts were made at the end of five days since normal bedbug eggs hatch within that period of time at 27 degrees C.

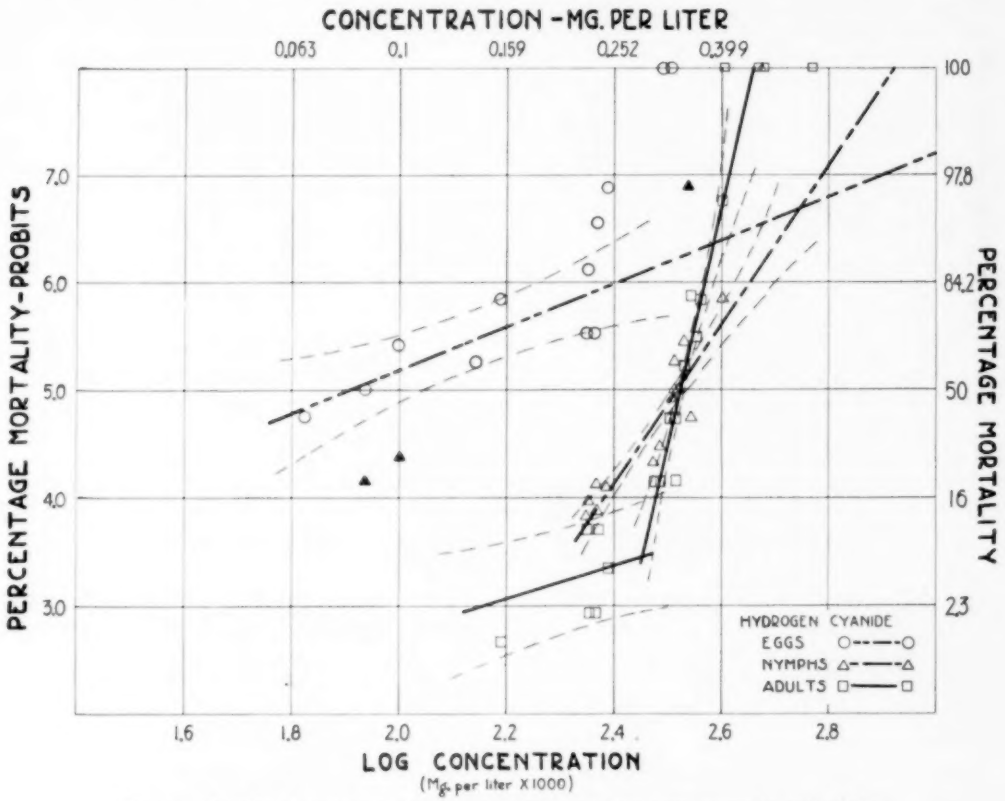

FIG. 1.—Results of tests with hydrogen cyanide against eggs, nymphs and adults of the bedbug, *Cimex lectularius* L.

RESULTS.—The results of these tests are given in table 1 and in figs. 1, 2 and 3. The curves presented in these figures are regression lines calculated according to the methods of Bliss (1935). The chi-square tests show that the results are consistent with those found by random

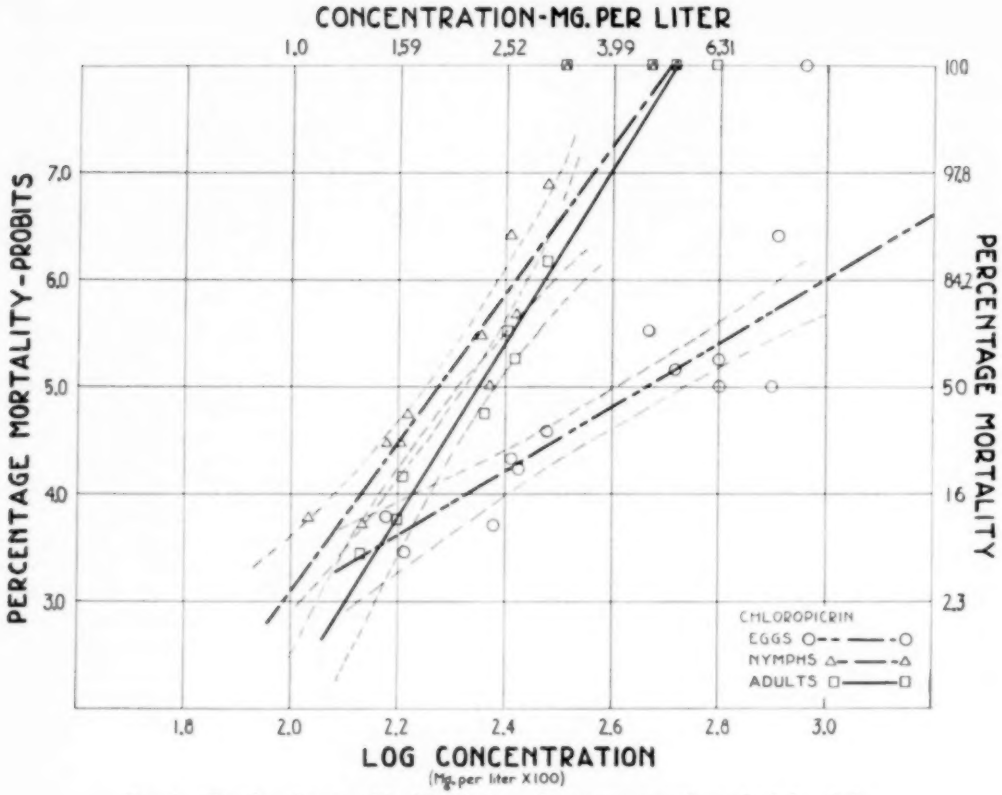

FIG. 2.—Results of tests with chlorpicrin against eggs, nymphs and adults of the bedbug, *Cimex lectularius* L.

sampling of a homogeneous population, except for the two curves showing the effect of chlorpicrin and ethylene oxide on bedbug eggs. The latter two curves, however, represent the best fit of the experimental data.

Table 1.—Median lethal concentrations of hydrogen cyanide, chlorpicrin and ethylene oxide against the bedbug.

STAGE	HYDROGEN CYANIDE, mg./liter	CHLORPICRIN, mg./liter	ETHYLENE OXIDE, mg./liter
Eggs	0.096	4.613	0.242
Nymphs	0.331	1.870	1.291
Adults	0.336	2.233	1.803

DISCUSSION OF RESULTS.—No definite statement can be made concerning the action of chlorpicrin and ethylene oxide on the eggs of *Cimex lectularius*, although it appears that bedbug eggs are more resistent to chlorpicrin than are nymphs or adults. These experiments tend to show that the ratio eggs:nymphs:adults at the M.L.C. is 2.5:1:1.2. Bertrand, *et al.* (1919) noticed this fact and stated that a second treatment might be necessary if any eggs escape the first fumigation. Braemer & Bloch (1924) used chlorpicrin against all stages of *Sitophilus oryzae* (L.) and found that the eggs of this insect were more resistant than any other stage. Hagen (1931) discovered that ordinary doses of chlorpicrin killed the adults of thrips and red mites but had no effect on the eggs of these forms. Lindgren & Shepard (1932) showed that, at low humidity, eggs of *Tribolium confusum* Duv. were 10.2 times more resistant to chlorpicrin than adults. At higher humidity the eggs were 3.6 times more resistant than the adults. Moore (1918) and Moore & Hirschfelder (1919) found that the eggs of the clothes louse were twice as resistant to chlorpicrin as adults. Peters (1936) showed that the ratio nymphs: adults of *C. lectularius* to chlorpicrin is 1:1.5.

Mayer (1934) states that when fumigated with T-gas (10 parts ethylene oxide and 1 part carbon dioxide) the nymphs of

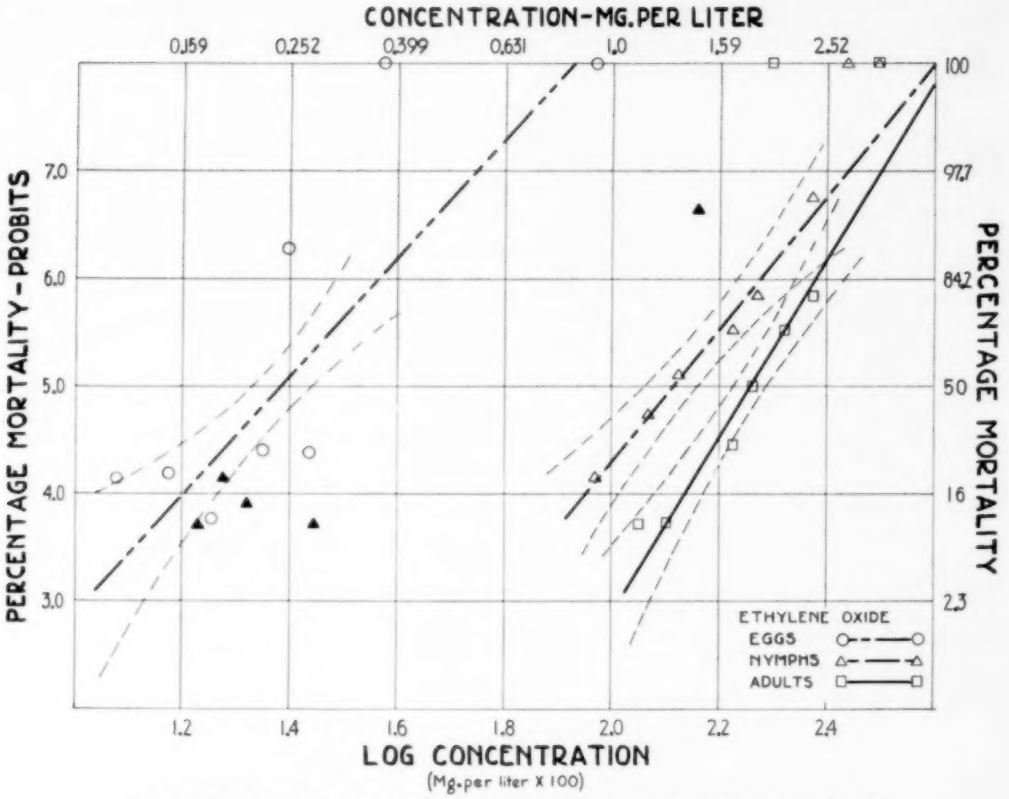

FIG. 3.—Results of tests with ethylene oxide against eggs, nymphs and adults of the bedbug, *Cimex lectularius* L.

the bedbug are twice as resistant as the adults and seven times as resistant as the eggs when dosage needed for 100 per cent mortality is used. The present experiments do not show such to be the case. At 100 per cent mortality (from the graph) the ratio nymphs:adults is nearly 1:1. The great differences given by Mayer may be due to the fact that carbon dioxide was present. The ratio eggs:nymphs:adults at the M.L.C. is 1.0:5.3:7.4. At the concentration causing 100 per cent mortality, Peters (1936) found that the ratio eggs:nymphs:adults was 1–1.5:6:4 for ethylene oxide. Hase (1932) found that nymphs and adults of *Cimex lectularius* were rather closely related in their resistance to ethylene oxide.

Hydrogen cyanide, from these experiments, appears to be more toxic to eggs than to other stages of the bedbug, the ratio eggs:nymphs:adults being 1:3.4:3.5. Peters (1936) found even less variation among the different stages of this insect. As shown by him, the ratio eggs:nymphs:adults is 1–1.5:2–4:1–2 at concentrations causing 100 per cent mortality.

The relative toxicity of hydrogen cyanide, ethylene oxide and chlorpicrin at the M.L.C. to bedbug eggs is 1:2.5:48.1; to nymphs is 1:3.9:5.6; and to adults is 1:5.3:6.6. Rosen (1932), apparently using Strand's (1930) figures, states that the relative toxicities of hydrogen cyanide, chlorpicrin and ethylene oxide are 1.0:7.74:16.0 to the adults of *Tribolium confusum*. It is interesting that with such widely different insects as the bedbug and the confused flour beetle the ratio of hydrogen cyanide to chlorpicrin should be so similar.

SUMMARY.—The experiments reported here show the variations among stages and among fumigants as used against the bedbug, *Cimex lectularius* L. No conclusions may be drawn as to the action of ethylene oxide and chlorpicrin on bedbug eggs. It is shown that hydrogen cyanide is from 2 to 48 times as toxic as the other gases used. Bedbug eggs are less resistant to hydrogen cyanide and ethylene oxide

than are nymphs and adults. The eggs are apparently much more resistant to chlorpicrin than are nymphs and adults. Nymphs and adults of the bedbug are very similar in their reactions to the fumigants used in these experiments.—5-23-38.

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A Consideration of Some Phases of the Mosquito Control Problem*

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The phases of the mosquito control problem which I want to call to your attention are those that have arisen as a result of the present country wide agitation for wildlife conservation and restoration. As most of you know, mosquito control work on marshes is being attacked in many localities as being destructive to wildlife habitats without bringing any appreciable relief from the mosquito pest. It is not my purpose to mention specifically any of the numerous attacks, but rather to make some suggestions as to what mosquito control workers can do to offset effectively some of the present criticism, part of which is decidedly unjust.

Salt-marsh mosquito control by marsh ditching is designed to remove water from the marsh surface after rains or high tides before mosquito larvae have time to mature, to make marshes subject to daily tidal action or to supply with insectivorous fish areas that are difficult to drain. Each of these measures involves changing to some extent the existing water conditions. If ensuing changes in environment are unfavorable to mosquito life, some effect must be expected on other forms of plant and animal life which thrive best under conditions that promote mosquito breeding. Marshes exist under such a variety of conditions that the changes in marsh life following ditching may be either slight or severe, depending on the extent to which the original water conditions are changed. In discussing mosquito control, persons antagonistic to the work usually stress conditions on those marshes where the effect of ditching on wildlife habitats is most severe, and imply that such conditions are universal, whereas if such persons have any knowledge of marsh conditions in general they

* Read before Florida Anti-Mosquito Association, twelfth annual meeting, Jacksonville, Fla., March 28–29, 1938.

must know that such implications are misleading. However, there is no question but that undesirable changes do occur on many marshes following ditching, and for this reason mosquito control should be justified on the basis of the actual relief from mosquitoes and not on the lack of injury to marsh conditions or their incidental improvement in certain cases as a result of the work.

JUSTIFYING CONTROL.—Where a considerable human population is affected or where the development of a community is being retarded because of mosquito infestation, it can usually be shown that the benefits to be derived from mosquito control, provided the expense is not prohibitive, far outweigh the damage, if any, which may result from the work in the vicinity. Where such is not the case, mosquito control should not be undertaken.

Even when a mosquito control project is thus economically justified and properly prosecuted there are likely to be some persons whose interests are not those of the community as a whole and who continually attempt to discredit the work. Furthermore, many persons who support the project at first may easily forget what the conditions were previous to mosquito control. It is advisable, therefore, to be ready to defend the work on the basis of what is being accomplished. A certain amount of information should be collected prior to beginning operations. This necessitates a careful survey to determine the abundance of mosquitoes and the species present, their breeding places, and, where marsh ditching is involved, the probable extent of this work necessary to secure reasonable control. Particular efforts should be made to obtain definite information on the normal density of the various species of adult mosquitoes before control is started, because real progress can be measured only in terms of diminished annoyance from the pests, or reduced incidence of mosquito-borne diseases. Results which stress miles of ditching per year or rate of ditching per man hour are sometimes hard to translate into relief from mosquitoes afforded by the work.

Mosquito control is primarily a biological problem and as such should be under the direction of a man who has had a sufficient amount of training in biological fields to appreciate and intelligently deal with the many factors involved in what is thought of by some people as a simple problem. Even though we know in general the types of marshes on which mosquitoes breed, it is often difficult to determine the comparative importance of these marsh types as mosquito producers in a given locality. To determine this importance, actual inspections of marshes must be made at various times when climatic conditions are favorable for mosquito production. It goes without saying, of course, that marshes should not be ditched for mosquito control until larvae have actually been found on them in important numbers, and that control operations should be started on those breeding areas closest to the community to be protected and extended only so far as is necessary to obtain satisfactory relief. Mosquito control workers would be in a much better position to defend their work against the charge of indiscriminate ditching and marsh ruination if records could be produced to show that such examinations had been made and that all marshes treated were known to be important mosquito producers.

MOSQUITO CONTROL AND WILDLIFE.—Inasmuch as the importance of preserving natural marsh habitats is becoming more and more apparent, it is well to invite cooperation by competent conservation authorities in making preliminary surveys of marshes in order that they may become acquainted with the mosquito control problem. Where it is necessary in the interest of control work to disturb any important wildlife area, an attempt should be made to secure the assistance of such authorities in working out methods of treatment designed to reduce possible injury. This does not mean that, when a community has decided for mosquito control, it should be necessary to have the project approved by sportsmen's associations before work is started.

I am sure that it is not the desire of mosquito control officials to interfere with wildlife any more than is absolutely necessary in order to accomplish the degree of mosquito control which is expected of them. Many of these men are carefully studying their projects and devising special treatments for areas which appear to have possibilities as wildlife habitats. For instance, it is often stated that the ponds are the life of the marsh as far as

waterfowl are concerned and that these ponds lose much, if not all, of their attractiveness as feeding areas when ditched in such a manner that they become practically empty at low tide. In the CCC camp work in Maryland, Delaware and New Jersey recommendations are being made at present that no permanent marsh pond be ditched unless a considerable mosquito breeding area is affected by it, in which case it is recommended that the pond be connected to the ditching system by a spur ditch that can be closed later if conditions warrant. In general these recommendations are being complied with. In Delaware and elsewhere many ponds that were ditched have been restored by the installation of various types of stoppage boards in their outlets. In Maryland and Delaware, where there is a considerable muskrat industry, dykes are being constructed in some areas to protect the fresh-water muskrat marshes from flooding by salt water. Natural run-off from such an impounded marsh is provided for by a tide and spill gate. This operates to hold water on the marsh high enough to preserve favorable conditions for the muskrat food plants and to prevent migratory mosquitoes from breeding. When conditions are such that a big brood of mosquitoes does get under way, the spill boards can be removed and the area drained. After a marsh has been treated by this method, evidence indicates that conditions favorable for muskrat production are greatly improved.

Mosquito-control men in New York, Rhode Island, Connecticut and various other states are now endeavoring to carry on their work in a manner that will affect wildlife on the marshes to the least extent possible.

At the recent convention of the American Wildlife Institute held in Baltimore, it was brought out that the duck population is increasing at present and that more or less satisfactory hunting conditions occurred along the Eastern Coast for the first time in several years. This increase is largely due no doubt to the stringent hunting regulations which have been in force recently, to the extensive acreage of marsh land now included in refuges where shooting is prohibited and to more favorable breeding conditions in the North. As has been contended by mosquito control workers, although the recent extensive mosquito control work may have contributed to the decrease of migratory waterfowl feeding and breeding grounds, drought in other breeding areas and overshooting chiefly have been responsible for the decline of ducks. Nevertheless, it is important that suitable marsh areas sufficient to supply the needs of these valuable birds be maintained. It is believed by many conservationists familiar with marsh conditions that these marsh areas can be maintained without the sacrifice of essential and justifiable mosquito control correctly conducted.

In closing I might say that I do not believe justifiable mosquito control projects will suffer as a result of the present attacks being made against the work. The rapidly growing interest in conservation and rehabilitation of wildlife feeding and breeding areas, however, demands that attention be given by mosquito control officials to this problem. On the other hand, there is a danger of producing serious mosquito problems by water impoundments for wildlife habitats and for erosion and flood control, and persons in charge of such projects should likewise give careful attention to the mosquito hazard involved in their work.—5-25-38.

Larval Development of the Native Elm Bark Beetle, *Hylurgopinus rufipes* (Eich.), in Massachusetts*

W. B. BECKER, *Massachusetts Agricultural Experiment Station, Amherst*

As part of a study of the development of *Hylurgopinus rufipes* (Eich.) beneath the bark of elm, the following experiments were conducted. Logs of the American elm, *Ulmus americana* L., between 5 and 8 inches in diameter and about 4 feet long, which had been cut from one tree, were laid horizontally in a single row

* Contribution No. 309 of the Massachusetts Agricultural Experiment Station.

across two other logs so they were raised slightly off the ground. The test logs were laid with the long axis in a northwest-southeast direction. They were under moderate shade in a wooded area. About once a week during the spring, summer and fall of 1936 when immature stages of only the first generation of the beetle were beneath the bark, a 4-inch cross section was cut from a log, and all the live stages of *H. rufipes* present were collected and preserved in 80 per cent alcohol. The bark on each cross section of log was cut into four quarters, which represented the top, bottom and two sides of the logs. One side faced the northeast and the other the southwest.

METHODS FOR DETERMINING NUMBER OF LARVAL INSTARS.—In an attempt to determine the number of larval instars which occurred most commonly, the author employed the following methods:

1.—Completed larval galleries were examined for the presence of cast larval skins among the frass. It was supposed that each skin found would indicate one larval instar. However, because these larval skins disintegrate and are hard to find, not many galleries were examined. Those skins which were found merely indicated that there was a variation in the number of stadia, as many as eight skins having been found in logs exposed to natural conditions in the field. The finding of cast skins, however, was very slow, difficult and too subject to error; so resort was made to the following method.

2.—The head-widths of numerous larvae of all sizes were measured to determine whether a definite number of stadia commonly occurred—a method reported to have been used successfully by Blackman (1915), Prebble (1933) and Bedard (1933), working independently on other bark beetles.

In our experiment the larvae were segregated according to the date collected and the quadrant of the log from which they were taken. It was assumed that if plotted on a graph which showed the size distribution, the head-widths of the larvae would fall into definite groups of sizes at fairly regular distances apart, these groups would appear as separate distinct peaks and each one would be considered indicative of the sizes occurring in larvae in one stadium. The number of these peaks would be considered indicative of the number of stadia.

As a partial check on the results of this method, the head-widths of larvae from the same location, known to be in the first and in the last stadium, were determined and compared with the grouping of sizes shown on the graphs. Tiny, unhatched larvae which were ready to break through their egg shell and also larvae which had just hatched, but which had not yet begun to dig or feed and were therefore in the first stadium, measured 0.234 to 0.344 millimeters across the head. The distribution of the sizes is shown in table 1. Large larvae which had stopped feeding and which soon transformed to pupae, and therefore were in the last stadium, measured from 0.750 to 0.922 millimeters. These size limits are shown on the graphs. So few larvae in the last stadium were measured that data concerning them is not presented in tabular form. The measurements given here set the approximate limits to the sizes of the first and last instars.

Table 1.—The head-widths of larvae known to be in the first stadium.

WIDTH OF HEAD, IN MILLIMETERS	NUMBER OF LARVAE
0.234	1
0.250	0
0.266	6
0.281	16
0.297	20
0.313	7
0.328	1
0.344	1

Naturally the ideal method of determining the number of stadia which occurs in a given species would be to observe the complete development of a large number of individuals, all of which have been exposed to the same normal conditions. Because this observation is rather difficult in work with bark-infesting species, in many instances one must resort to a method such as that used here. The author's interpretation of the results obtained are discussed in the following pages.

LARVAE COLLECTED AT WEEKLY INTERVALS.—Figs. 1–6 and table 2 show the size distribution of the head-widths of one generation of larvae collected at approximately weekly intervals throughout

the spring, summer and fall of 1936. The larvae from all four quadrants of the logs are included.

Fig. 1 shows the distribution, on the basis of the head-widths, of all larvae (223) collected June 22, 1936. The tall peak at the left indicates the abundance

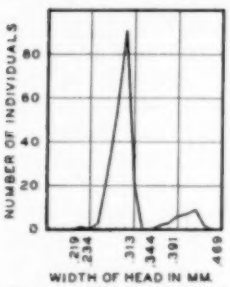

FIG. 1.—The size distribution of the head-widths of all larvae (223) collected June 22, 1936. Each horizontal division equals 0.015625 millimeter.

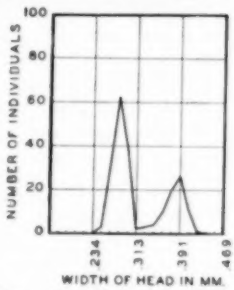

FIG. 2.—The size distribution of the head-widths of all larvae (212) collected June 29, 1936. Each horizontal division equals 0.015625 millimeter.

of larvae in the first stadium. All measurements in it fall within the known limits common to larvae in the first stadium. The small peak at the right indicates the presence of a few larvae in the second stadium. (One week previously, on June 15, only two larvae were found. Both were in the first stadium.)

Fig. 2 shows the distribution, on the basis of the head-widths, of all larvae (212) collected June 29, 1936. This figure is similar to fig. 1, except that it indicates an increase in the proportion of larvae in the second stadium at this date.

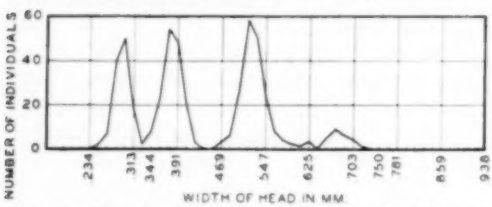

FIG. 3.—The size distribution of the head-widths of all larvae (486) collected July 6, 1936.

Fig. 3 shows the distribution, on the basis of the head-widths, of all larvae (486) collected July 6, 1936. The three distinct peaks shown here indicate the presence of approximately equal numbers of larvae in the first three stadia and also the appearance of a few larvae in the fourth stadium.

Fig. 4 shows the distribution, on the basis of the head-widths, of all larvae (506) collected July 13, 1936. At this date, head-widths known to occur in larvae in all stadia were present, but those occurring in larvae in the first three stadia, especially the first, were beginning to decrease in number. It seems likely that most of the head-widths in the large group between 0.563 and 0.719 millimeters belonged to larvae in the fourth stadium, since the whole group appeared at the same date. If one assumes a fairly regular rate of growth with regard to both size and time of appearance of the successive instars for a large group of

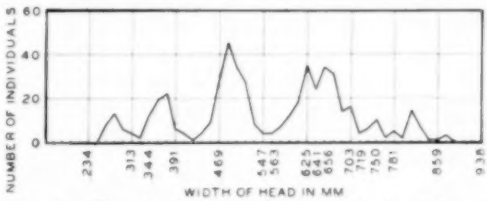

FIG. 4.—The size distribution of the head-widths of all larvae (506) collected July 13, 1936.

larvae, this supposition is strengthened. The dip in the graph at 0.641 in the center of this group of measurements appears in other graphs and is discussed later in the reference to fig. 11. The lack of a definite group of larvae of a larger size at this time indicates that not many had reached this stage of development.

Fig. 5 shows the distribution, on the basis of the head-widths, of all larvae (550) collected July 22, 1936. Head-widths known to occur in larvae in all stadia were still present. The distinct peak at the right indicates an abundance of head-widths known to occur in the last stadium. The earlier instars, shown by small peaks on the graph, were becoming

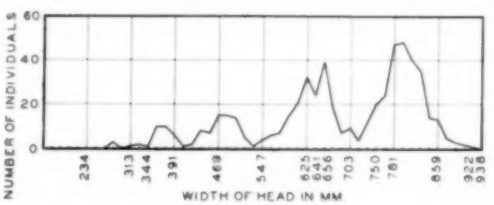

FIG. 5.—The size distribution of the head-widths of all larvae (550) collected July 22, 1936.

less distinct, indicating that there were fewer of them, the egg-laying season apparently being almost over. It will be ob-

Table 2.—The head-widths of larvae collected after July 29, 1936.

WIDTH OF HEADS IN MILLIMETERS	NUMBER OF LARVAE											
	August				September					October		
	4	11	18	26	1	11	15	24	29	7	15	21
0.484*												
0.500		1										
0.516	1	1										
0.531		3										
0.547	1											
0.563	2				1							
0.578	1		1	1								
0.594	1		1									
0.609	1		2	1	1							
0.625	2		2									
0.641	3	2	1								1	
0.656												
0.672		2	1	1							1	
0.688	2				1							
0.703	1	2	1	1	1							
0.719	1	3										
0.734	2	4	1	1	1			1				
0.750	2	3		1								
0.766	3	5	4	4	2						1	
0.781	9	8	3	2								
0.797	6	4	2	1			1	1			1	
0.813	5	8			2		1				1	
0.828	2	2	1	2	1	1					1	
0.844	8	1		1	2			1			2	
0.859	2	1		1							2	
0.875	1											
0.891	2											1
0.906												
0.922												
0.938												

* Head widths of this size and smaller were not found on these dates in the logs used for this experiment.

served that the dip in the graph at 0.641 which occurred in the preceding graph, also occurs here.

Fig. 6 shows the distribution, on the basis of the head-widths, of all larvae (406) collected July 29, 1936. Head-widths occurring in all larval instars were present, but the smaller sizes were becoming scarce, and there were no definite groupings of the sizes among them. Many head-widths known to occur in the last larval instar are recorded here, but the grouping was irregular, two high peaks being present. On the graph depicting the total number of head-widths recorded for the season, two peaks also appeared in this group. This condition is discussed later under reference to fig. 11.

The head-widths of the relatively few larvae found on succeeding dates are presented in table 2. It will be observed that, beginning with the head-widths found in the first instar, those occurring in the earlier instars slowly disappear.

LARVAE COLLECTED FROM QUADRANTS OF LOGS.—The graphs shown in figs. 7, 8, 9 and 10 present the size distribution,

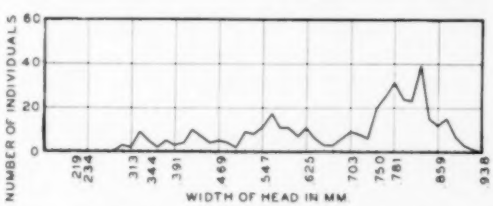

FIG. 6.—The size distribution of the head-widths of all larvae (406) collected July 29, 1936.

on the basis of the head-widths, of all the larvae which were collected from each quadrant of the logs all season. It was thought that the sameness of environ-

ment might cause a definite number of stadia to occur in a single quadrant.

Fig. 7 shows the distribution, on the basis of the head-widths, of 875 larvae collected all season from the top of the logs. This indicates the common occur-

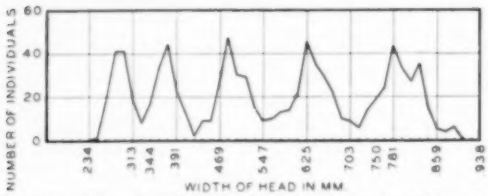

FIG. 7.—The size distribution of the head-widths of 875 larvae collected all season from the upper quadrant of the logs.

rence of five successive stadia and the head-widths common to each instar. The first peak on this graph coincides with the head-widths of larvae known to be in the first stadium. The next three peaks are distinct enough to indicate that most of the larvae of these sizes were in three successive stadia. The head-widths most common to each instar are also indicated. The last peak on the right has two points. Both of these points, in fact the major portion of this peak, fall within the size limits known to occur in larvae in the last

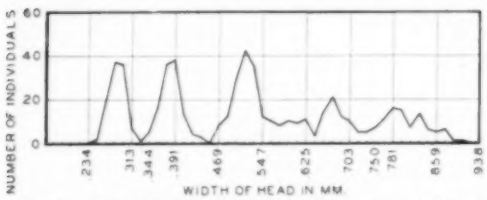

FIG. 8.—The size distribution of the head-widths of 561 larvae collected all season from the southwest quadrant of the logs.

stadium so that most of the head-widths represented in this peak probably are those of larvae in the last stadium. The two points on this peak may be due to natural variations, or, as discussed under the reference to fig. 11 where a similar condition is present, may suggest a possible difference in size due to sex. It would have been desirable to have obtained more specimens from this quadrant.

Fig. 8 shows the distribution, on the basis of the head-widths, of 561 larvae collected all season from the southwest side of the logs. The three distinct peaks at the left clearly indicate that three successive larval instars commonly occurred in individuals of these sizes. The head-widths common to each are also indicated. The grouping of the larger head-widths which occurred in later instars is not definite enough to indicate anything, probably because not enough of these larvae were present in this quadrant. However, if one is to assume a fairly constant rate of growth for most of the larvae as they pass through successive stadia, there is room for only one instar to occur between the third, as indicated on the graph, and the last, which the measurements of lar-

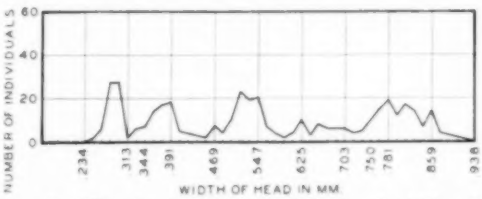

FIG. 9.—The size distribution of the head-widths of 406 larvae collected all season from the northeast quadrant of the logs.

vae known to be in the last stadium show to be from 0.750 to 0.922 millimeters. This graph then suggests that five instars must occur most frequently here. Nevertheless, as discussed later in more detail, a variation in the number of stadia or a variation from a regular rate of growth is more apt to occur among larvae in the later stadia than among larvae in the earlier ones, due in part no doubt to the

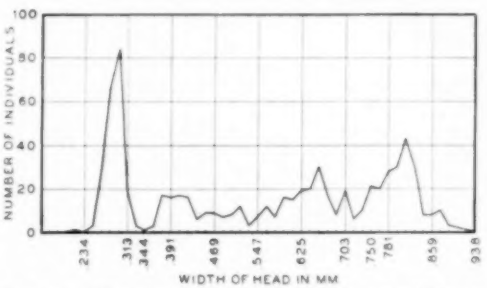

FIG. 10.—The size distribution of the head-widths of 791 larvae collected all season from the lower quadrant of the logs.

development of more diverse environmental conditions.

Fig. 9 shows the distribution, on the basis of the head-widths, of 406 larvae collected all season from the northeast side of the logs. The distinct grouping of sizes is not nearly so definite as in figs. 7 and 8, although small blunt peaks occur

at places which in those two figures are occupied by three very distinct peaks. Not enough larvae were collected from this quadrant of the logs to indicate how many stadia occurred most commonly.

Fig. 10 shows the distribution, on the basis of the head-widths, of 791 larvae collected all season from the bottom of the logs. The only definite peaks occur within the limits of size already known to be common in larvae in the first and in the last stadium. There is no definite grouping of the sizes common to the intermediate instars on this graph; so the number which occurs is not indicated. Evidently not enough larvae in the intermediate instars were present in this quadrant of the logs.

LARVAE COLLECTED ALL SEASON FROM ALL QUADRANTS OF LOGS.—In fig. 11 the solid black line shows the distribution, on the basis of the head-widths, of the 2,561 larvae which were collected all season from all sides of the logs used in this experiment.

There is some variation in the number of stadia as shown by actual count of the cast larval skins in completed galleries and as shown by the work of Kaston & Riggs (1937) on this species. Nevertheless, it is believed that this graph indicates that five stadia occurred most commonly under the conditions of this experiment. In fig. 11 variation is allowed for by the fact that some larvae occurred at all units of measurement, and that none of the peaks on the graph is definitely separated from any of the others. This arrangement of the peaks also allows for some overlapping in the sizes of larvae in adjacent stadia, as demonstrated by the fact that the largest widths known to occur in larvae in the first stadium appear under the peak which indicates larvae in the second stadium in fig. 11 and also on some of the other graphs. If more larvae found to be in the last stadium were measured, overlapping in the size of the head-widths of larvae in the last and next to last stadium would undoubtedly be found.

The fact that most of the irregularities on the graphs in figs. 1–6 and in fig. 11 are in the larger sizes indicates that most of the variations in size occur in the later instars. This indication is also supported by the fact that from left to right, on most of the graphs, each peak has a broader base than the preceding peak on the left.

It is known that environment can influence the number and size of larval instars. A study of the environment of *Hylurgopinus rufipes* in and beneath the bark shows that most of the young larvae dig in the inner bark next to the cambium and each one digs through sound bark. As the larvae grow and riddle the bark with

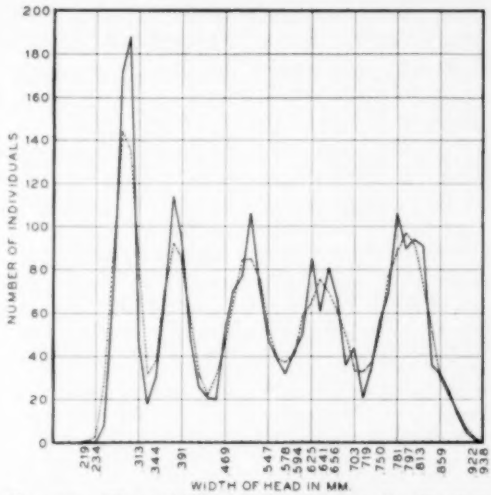

FIG. 11.—The solid line shows the size distribution of the head-widths of 2,561 larvae collected all season from all sides of the logs. The dotted line represents a three point moving average of the size distribution of the head-widths of the same larvae. In the event the irregularities in the solid line are due to the mechanics of measuring, the dotted line indicates the number of instars more clearly.

closely placed galleries, some continue to dig next to the cambium, but many enter the inner bark and dig at various depths. The galleries of slow-digging larvae may be cut off by those of faster-digging ones around them, causing the slower individuals to dig through the frass and excrement which are packed in the surrounding galleries, unless they can avoid them by diverting their course. Thus it is seen that the older larvae meet quite a variety of conditions, whereas the young larvae meet fairly uniform conditions. It might be expected, then, that the number of stadia and the sizes of the individual larvae in each would be more nearly uniform for the young larvae than for the older ones. This condition is brought out more strongly in the series of graphs (figs. 1–6) showing the head-widths collected on successive dates on all sides of the logs than in the series of graphs (figs. 7–10) showing the head-widths collected all season on the

individual sides of the logs. In the latter series it is likely that there were not enough individuals in the various stadia for this kind of graph. It is interesting to note that Kaston & Riggs (1937) find a "positive correlation between the number of instars and the duration of the entire larval period."

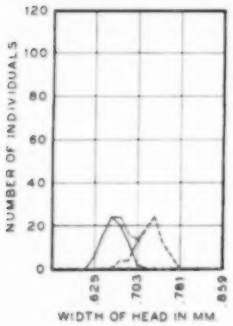

FIG. 12.—The solid line shows the size distribution of the head-widths of 40 adult males. The line of dashes shows the size distribution of 40 adult females. The dotted line shows the size distribution of both sexes when individuals of the same size are added together regardless of sex. All adults were selected at random from emergence cages at the site of the experiment.

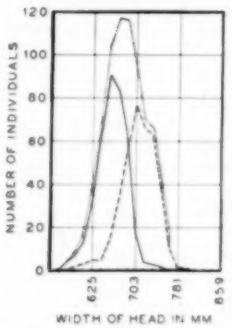

FIG. 13.—The solid line shows the size distribution of the head-widths of 383 adult males. The line of dashes shows the size distribution of 374 adult females. The dotted line shows the size distribution of both sexes when individuals of the same size are added together regardless of sex. All adults were selected at random from emergence cages at the site of the experiment.

COMPARISON OF MALES AND FEMALES.—Because this species is monogamous and the sexes are almost equal in numbers,† the two points at the top of the fourth and fifth peaks from the left on fig. 11 seem to suggest the possibility that, in this species, a slight difference in the distribution of sizes, which is due to sex, begins to become apparent in larvae in the last two stadia. This was considered likely since a slight difference exists between the size distribution of the head-widths of the male and female adults, the average size of the females being larger, as the two overlapping peaks on the graph in fig. 12 indicate. This graph shows the size distribution by head-widths of 40 male and 40 female adults selected at random. When the head-widths of the males and females were added together without regard to sex, and plotted, the size distribution was such that one broad peak with a double point resulted. The cleft between the two former overlapping peaks becomes less pronounced and the one resultant double-pointed peak strongly resembles the double-pointed peaks on fig. 11, which for the most part it is believed, represent the size distribution of larvae in the fourth and fifth stadia.

By measuring the head-widths of more male and female adults, however, it was found that, although the size distribution of the males remained distinct from that of the females, the size distribution of various groups of one sex varied, causing a variation in the extent of overlapping in the sizes of the two sexes. When the head-widths of some groups of males and females were added together without regard to sex, and plotted, it was found that in some cases the overlapping in the sizes of the two sexes was so great that only one large, single-pointed peak resulted, thus obscuring the difference between the size distribution of the two sexes.

In fact, when the head-widths of all the males (383) and all the females (374) which were selected at random from those emerging from cages at the site of this experiment were measured, added together and plotted, one blunt, single-pointed peak resulted, as shown in fig. 13. The peak including both sexes, however, is broader than either one which illustrates the size distribution of only one sex. This suggests the possibility that the broader bases of the peaks depicting the larger larvae may be at least partially due to the development of a difference in the size distribution in the larger larvae caused by sex. Whether one or two points occur on such a peak evidently depends on the extent of overlapping in the sizes of those male and female adults which are measured. Therefore, although the results obtained in this experiment are suggestive of a difference in the size distribution of the head-widths of the larger larvae which is due to sex, they cannot be considered conclusive. Evidence of a more definite nature is needed.

If there is a difference in the number of instars due to sex, it is not evident on these graphs.

It was interesting to note that, among 1,149 larvae which were reared at the same location in 1935, the larger head-

† Among 757 adults which emerged from caged logs at the site of this experiment, 374 were females, whereas 383 were males.

widths were grouped like those of the larger larvae indicated in fig. 11, which were reared in 1936. When the head-widths were plotted on a graph, two double-pointed peaks appeared at about the same units of measurement occupied by similar peaks on the graph in fig. 11. In 1935, however, the larvae were collected at irregular intervals from a few logs scattered throughout two log piles. Most of these were collected in the latter part of the larval period. As a result, not enough individuals in early stadia were measured to show any definite grouping of these sizes.

INTERPRETING THE DATA.—When interpreting the figures shown on graphs like these, one must take into consideration the mechanical factors involved in measuring and plotting such data. These might cause some irregularity.

1. In the first place, unless there is an abundance of material representing all the forms to be considered, the grouping of the various sizes is not apt to indicate the true conditions. It is also likely that the measuring of specimens reared in one environment will give better results than the measuring of specimens selected from material collected in several different environments.

2. When any series of objects is measured, some will fall approximately halfway between two units of measurement. Under which measurement they will be recorded depends on the judgment of the worker; some are recorded under one and some under the other. If more are recorded under one than under the other, an irregularity will occur in the normal grouping of the sizes. To straighten out any such irregularity on the graph in fig. 11, a three point moving average graph was drawn. This is shown as a dotted line. If the irregularities on the solid black line depicting the actual measurements are due to this cause, the five distinct peaks on this dotted line show a clearer picture of the number of stadia which occurs most commonly, and also the distribution of the sizes in each. Although five stadia evidently occurred most commonly, it is the opinion of the author that the two points on the top of each of the two peaks on the right in fig. 11 are not due to mechanical errors.

As already indicated, the larvae in each succeeding stadium varied more in size than the larvae in the previous one. To measure larvae in all stadia, units of measurement of a uniform size were used. When the head-widths of an ample number of larvae in the first stadium are measured with such a scale, when the result is plotted and such head-widths as those shown here are grouped on a graph, a tall, narrow, fairly uniform peak with abrupt sides will appear. If an equal number of larvae in the last stadium are measured, because these vary more in size, they will cover more units of measurement, and there will not be as many individuals in each size class. When the resultant grouping is plotted, the peak will be shorter and broader, covering more units of measurement, and will have less perpendicular sides. The latter peak is more apt to show irregularities than the former, but, if enough larvae are measured, any characteristic grouping of the sizes should be indicated more clearly.

If the larvae in both the first and last stadia show the same characteristic grouping of the sizes, in order to have the peak showing the size distribution of larvae in the last stadium appear on the graph just as tall, narrow and smooth as the first, it would be necessary to use the same *number* of units of measurement to measure the head-widths of larvae in both stadia. The individual units used for larvae in the last stadium would then naturally be larger because of the wider variation in size. When plotted on a graph, the divisions used in the plotting of both instars would have to be of equal size. In this way, the grouping of head-widths of larvae in the last stadium would appear on the graph as tall and abrupt as those in the first stadium and with the same approximate degree of smoothness.

In this instance, however, there is a possibility that an attempt to straighten out irregularities supposed to be due to the mechanics of measuring might obscure a natural variation in the grouping of the sizes of each larval instar. Incidentally, in addition to the possibility mentioned previously, that in this species a variation in size which is due to sex may begin to become apparent in fourth-instar larvae, part of the reason that the first three instars do not show this variation may be the fact that the early instars are more uniform in size than the later ones. There-

fore it is quite probable that any difference in size distribution due to sex would be comparatively smaller and would not be brought out by the units of measurement used. In addition, the sizes of the two sexes might overlap more than in the later instars.

Table 3.—The size distribution of the head widths above 0.578 millimeter, when the number of larvae occurring at every two successive units of measurement are added together.

WIDTH OF HEAD IN MILLIMETERS	NUMBER OF LARVAE
0.578 plus 0.594	74
0.609 plus 0.625	135
0.641 plus 0.656	142
0.672 plus 0.688	102
0.703 plus 0.719	65
0.734 plus 0.750	91
0.766 plus 0.781	176
0.797 plus 0.813	184
0.828 plus 0.844	127
0.859 plus 0.875	56
0.891 plus 0.906	18
0.922 plus 0.938	2

It will be noticed in fig. 11 that the double points on the two peaks at the right are only two units of measurement apart. Larger units of measurement probably would not have indicated this variation. To illustrate this last statement table 3 was prepared. It shows the grouping of the head-widths found in the two double-pointed peaks at the right of fig. 11, when the number of individuals occurring at the 0.578 and 0.594 millimeter units of measurement are added together and the same is done with every two units thereafter. This produced approximately the same effect on these groupings of measurement as would be obtained by use of units of measurement twice as large as those used for the first larval instar. (Except for one larva which was removed from an egg, all head-widths known to occur in the first stadium occupied 6 units of measurement, whereas those actually known to occur in the last occupied 12. In addition, the peak indicating the first larval instar is slightly less than one-half as broad as the double-pointed peak at the extreme right, and is slightly more than one-half as broad as the group between 0.578 and 0.719 millimeters.) It will be observed from table 3 that if a size distribution graph were made from the resultant figures, the peaks would not have the double-pointed tops.

A summary of the requirements for measuring the head-widths of larvae indicate that the units of measurement must be small enough to show all natural and important variations in size, where possible. In addition, enough specimens should be measured to show any natural grouping which may occur. Best results are obtained probably when measurements are taken of larvae all of which have been reared under similar environmental conditions.

SUMMARY.—The count of cast larval skins in several completed galleries of *Hylurgopinus rufipes* (Eich.) indicates that there may be a variation in the number of stadia of this beetle. The results obtained, however, by plotting on graphs the size distribution of the head-widths of one generation of larvae which were collected at approximately weekly intervals, indicate that five stadia occurred most commonly under the conditions of the experiment. The results also indicate an overlapping in the sizes of the head-widths of successive larval instars and allow for a variation from this number of instars for some of the larvae. In addition, because the species is monogamous and the sexes are almost equal in number and because there is a difference in the size distribution of the head-widths of the male and female adults, the data suggest the possibility that a difference in size distribution due to sex may begin to become noticeable in the last two instars. The possibility of such a difference in size, however, is not determined by this experiment. Evidence of a more definite nature is required.—6-8-38.

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Wireworm Damage to Potatoes in the Yakima Valley of Washington

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Wireworms are generally considered one of the major insect pests of potatoes in this country. Many investigators in various states have reported wireworm damage to potatoes as of considerable economic importance. Hawkins (1930), in Maine, reports injury both to potato plants and to the tubers by wireworms. Rawlins & MacLeod (1935) report the wheat wireworm, *Agriotes mancus* (Say), and the eastern field wireworm, *Limonius ectypus* (Say), as injurious to potato tubers in certain potato growing districts of New York state. Glen, King & Arnason (1936) report wireworms as doing serious and widespread damage to potatoes in the Province of Saskatchewan, Canada. Hawkins (1936) points out that potatoes are a crop particularly susceptible to wireworm attack in Maine and the greatest annual loss to the crops of that state is that caused to potatoes by wireworms. Reports indicating similar damage have been made by many state and federal workers.

Research investigations on wireworms as truck and garden crop pests in the Pacific Northwest have indicated that 100 per cent control under field conditions is not always feasible. It was decided, therefore, to determine whether any correlation existed between wireworm populations in the field and the degree of injury to potatoes. Information on this relationship would be of commercial value in deciding when potatoes could be safely planted to avoid serious damage from wireworms.

INVESTIGATION PROCEDURE.—This work was begun in the spring of 1932 and carried on throughout the seasons of 1932 and 1933 in 27 different fields. The two predominating species of wireworms found in the fields in which this work was carried on were the Pacific Coast wireworm, *Limonius canus* LeC., and the sugar-beet wireworm, *Limonius californicus* (Mann.). A few representatives of other species were found, but not in sufficient numbers to be of economic importance; these included *Drasterius* sp., *Cardiophorus* sp., and *Dalopius* sp.

Soil siftings were made early in the spring, following the sampling method described by Jones (1937), before adults emerged and before potatoes were planted in these fields. The number of samples taken in each field varied according to the size and indicated population of the field. The minimum number of samples taken in each field was 25 and the maximum number 100. The average was 50 samples per field for the 27 fields.

The unit used for soil siftings was 1 square foot of soil surface, and all samples were taken entirely at random. Each sample unit was removed in 3-inch layers to a depth sufficient to obtain all the wireworms, which was usually 18 inches. Each 3-inch layer was sifted separately through a series of metal screens on a power-driven mechanical sifter developed by Lane & Shirck (1936). After most of the soil had passed through the screens, the wireworms were readily seen and removed for counting.

The mean and the standard error of the wireworm populations of the various fields were calculated in terms of the number of larvae per square foot. The error of estimate was less than 30 per

* All work reported in this paper was carried on under the direction of M. C. Lane, to whom the author is indebted for helpful suggestions and criticisms in preparation of this paper

Table 1.—Wireworm populations of potato fields and per cent damage to the crop.

Field No.	Year	Size in Acres	Wireworm Population Per Square Foot	Pounds of Potatoes Sorted	Per Cent Damage		
					Light	Heavy	Total
1	1932	2	0.09±0.03	796	6.81	1.06	7.87
2	1933	1	0.16±0.05	520	9.32	1.09	10.41
3	1933	1	0.28±0.08	817	17.25	6.50	23.75
4	1932	1	0.32±0.09	712	8.93	0.00	8.93
5	1932	1	0.32±0.12	734	16.75	5.34	22.09
6	1932	½	0.36±0.17	607	15.43	4.27	19.70
7	1932	½	0.48±0.13	1298	21.82	8.32	30.14
8	1932	⅒	0.60±0.22	332	31.34	17.84	49.18
9	1932	½	0.67±0.17	803	27.15	9.58	36.73
10	1933	2	0.79±0.12	1058	32.60	22.37	54.97
11	1932	½	0.86±0.16	1823	27.24	14.85	42.09
12	1933	1	0.98±0.14	1252	23.65	14.39	38.04
13	1932	½	1.18±0.28	873	33.25	11.26	44.51
14	1932	½	1.30±0.16	3115	15.14	5.75	20.89
15	1932	⅙	1.57±0.21	300	18.00	19.20	37.20
16	1933	½	1.78±0.27	442	32.87	27.02	59.89
17	1933	1	2.06±0.36	625	39.07	18.98	58.05
18	1932	½	2.16±0.42	282	26.96	27.14	54.10
19	1932	¼	2.60±0.32	574	32.83	35.92	68.75
20	1932	¼	2.74±0.47	945	23.85	6.74	30.59
21	1932	½	2.90±0.42	1376	31.95	24.52	56.47
22	1932	⅙	3.14±0.42	319	28.90	16.00	44.90
23	1932	⅙	3.94±0.51	1051	26.51	39.76	66.27
24	1932	⅙	4.54±0.48	1403	19.98	61.27	81.25
25	1933	¼	5.36±0.50	724	18.02	65.17	83.19
26	1932	½	5.40±0.56	1201	29.31	33.14	62.45
27	1932	¼	7.66±0.80	1967	17.63	60.84	78.47

cent in 22 fields and less than 20 per cent in 17 fields. This is accepted as a fairly accurate estimate of the wireworm populations in this study.

Potatoes were grown as a commercial crop in all the fields after wireworm numbers had been determined in the spring. When the potatoes were harvested in the fall the fields were again visited, a number of potato samples taken at random from each field, and damage counts made. These samples were of various quantities,

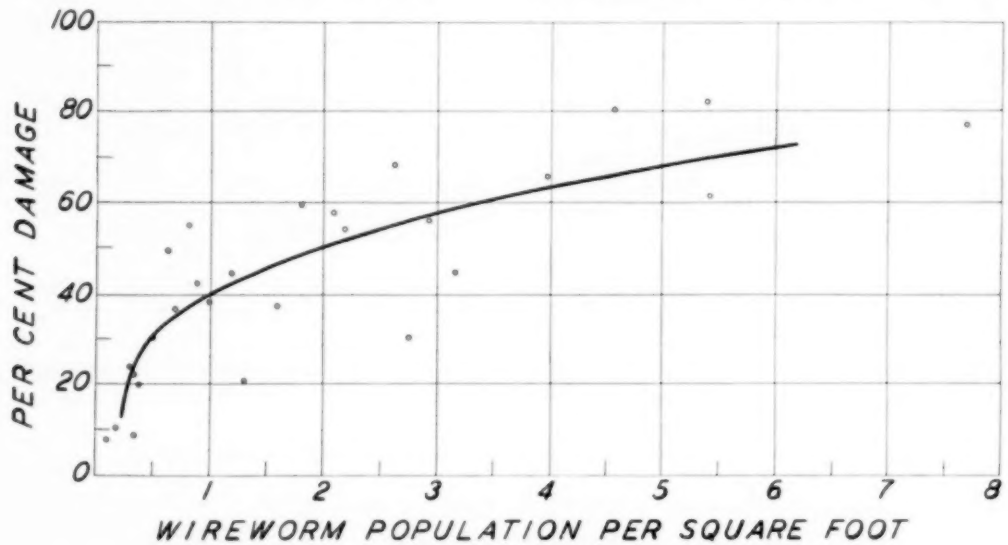

FIG. 1.—The relation of field populations of wireworms to potato damage.

each depending on the size of the field in which it was taken. They were sorted in the field and segregated into classes according to the degree of injury apparent on the tubers, as follows: Those free from wireworm injury; those lightly damaged, including one and two entrance holes per tuber; and those heavily damaged, including three or more entrance holes per tuber. The percentage of tubers damaged and undamaged was calculated on the basis of weight rather than count, since the potatoes were sorted just as they were dug from the field and were not of uniform size. In many instances the very small tubers showed a smaller percentage of damage by count than the larger ones. Since sale value, and consequently crop value, is based on a weight figure, total per cent damage by weight rather than by count presents a more accurate picture of the situation.

RELATIONSHIP BETWEEN WIREWORMS AND DAMAGE.—Table 1 shows the relationship that has been established by determining the numbers of wireworms in these 27 fields and subsequently checking the damage to the potato crop. The fields have been arranged in order in the table according to ascending wireworm populations. The standard error for each population estimate is shown, and also the weight of the potato sample from each field.

The data in table 1 show that in most cases where the wireworm population is less than 0.5 per square foot the potato crop shows less than 25 per cent total damage. Between 0.5 and 1.0 wireworm per square foot, the damage rises to approximately 50 per cent. At a population of 2 worms a total damage of nearly 60 per cent has been reached and the damage rises slowly from this point to a maximum of slightly over 80 per cent as the population approaches a high point of 7.6 wireworms per square foot. The data indicate that total wireworm damage to potato crops does not show a regular proportional increase with the increase in wireworm numbers, although the general trend is definitely toward greater damage. Light damage, including one and two entrance holes per tuber, increases very quickly, reaching a peak at about 0.8 wireworm per square foot, and on the average does not increase beyond this point; in fact, it tends to decrease slightly at the higher population levels. The heavy damage, on the other hand, shows on the whole a very consistent and steady increase as the population rises.

Table 2.—Averages of wireworm population and damage for six groups of potato fields.

GROUP	FIELDS	WIREWORM POPULATION PER SQUARE FOOT	PER CENT DAMAGE		
			Light	Heavy	Total
1	1 to 4	0.21	10.58	2.16	12.74
2	5 to 8	.44	21.34	8.94	30.28
3	9 to 14	.96	26.51	13.03	39.54
4	15 to 20	2.15	28.93	22.50	51.43
5	21 to 24	3.63	26.83	35.39	62.22
6	25 to 27	6.14	21.65	53.05	74.70

These data have been plotted in fig. 1, the per cent damage to the potato crops, field by field, being represented by the small black circles. A line or curve drawn through all these circles would show no smooth progression of damage corresponding to populations, but when the fields were grouped and averages made for population and damage counts the relationship was evident. The figures for this grouping, taken directly from table 1, are presented in table 2 and plotted in fig. 1. The curve drawn through the points thus established shows a regular increase in damage corresponding very well with the average population increase.

Fig. 1 indicates that a comparatively large amount of damage is done by a small number of wireworms. The damage curve rises very rapidly with an increase in wireworm population, but tends to reach a near-saturation point at a comparatively low level. Fields with an average population of 0.2 wireworm per

square foot show an average total damage to the crop of 12.7 per cent. When this population is a little more than doubled, the rate of damage is increased by 17.4. However, with an increase in population from 0.44 to 0.96 per square foot, or doubled again, the rate of damage is increased by only 9.3. From this point the damage curve begins to straighten, indicating a regular but much less rapid increase in damage in relation to population at the higher levels. Hawkins (1934) found that in the potato fields in Maine there was a definite relationship between the number of wireworms per soil sample and the average percentage of injured tubers.

The small black circles in fig. 1, representing damage counts in the individual fields, fall both above and below this line of averages, indicating that damage to the crop is sometimes more and sometimes less than might be expected according to the number of wireworms in the field. Arithmetical averages of population and damage were also determined for the entire 27 fields as one unit. The average wireworm population was 2.0 per square foot, 23.4 per cent of the tonnage of potatoes sorted incurring light damage, and 20.7 per cent heavy damage, the average total damage amounting to 44.1 per cent. Indications are that with information only as to the wireworm population of a field, it would not be possible to predict the extent of damage to a potato crop, except in a general way. Irregularities in total damage figures as compared to regular ascending field population figures are distinctly shown in fields 14 and 20 (table 1) where the damage was much less than would be anticipated. Such irregularities probably result from variations in one or more of the following factors which might influence damage: Date of planting; method of irrigation, including frequency and quantities of water applied; or possibly a variation in soil type, especially with reference to water holding capacity.

All figures presented in this paper representing damage or injury are given purely as mechanical indications of injury and without regard to their commercial significance. Most potatoes containing only one or two entrance holes per tuber will make satisfactory and profitable commercial grades if otherwise salable. A crop showing up to 5 per cent heavy damage and less than 25 per cent total damage is comparatively clean from a commercial point of view. Damage figures above this soon force a heavy loss in grading and consequently a rapidly mounting financial loss due to wireworms. In order to grow a comparatively clean commercial crop of potatoes, it is necessary to have a field where the wireworm population is not over a maximum of 0.5 per square foot. Generally speaking, such a population will injure less than 25 per cent of the weight of the tubers, and many of those injured can be sorted into marketable grades.

SUMMARY.—Wireworm injury to potatoes is in a general way related to the numbers of wireworms in the soil, but other factors than numerical abundance of these pests may have considerable effect on their depredations.

No definite forecast of the damage that may be incurred can be made on the basis of wireworm population, but it seems that with a population of 0.5 wireworm per square foot approximately 25 per cent of the crop may be damaged. The injury will rise with increasing numbers of wireworms until after six or seven wireworms per square foot are found, when the added damage may be relatively little.—7-18-38.

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Observations on the Nature of Bulb Mite Attack on Easter Lilies

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For many years greenhouse operators who force Easter lily bulbs (*Lilium longiflorum*) have been troubled by bulb mites, *Rhizoglyphus hyacinthi* Bdv., attacking the plants. The mites tunnel the stems at the ground level, causing them to lean or break at that point. Lily plants that fail to develop properly are also often infested in the lower stem region. It has been generally assumed in entomological literature that such attack is primary in nature, and control of the mites is recommended.

Studies were begun in 1935 to gain further information on the causes of, and controls for, this type of injury. Tests were carried on at the laboratory greenhouse and numerous observations were made in commercial greenhouses.

TESTS.—Repeated trials were made to produce injurious effects: selected lily bulbs carrying moderate natural infestations were forced, and large populations of bulb mites were introduced on to lily bulbs. The introduced colonies were transferred from narcissus bulbs by a water suspension of mites poured between the lily scales and by a piece of heavily infested narcissus bulb placed beneath outer scales of lily bulbs. Negative results were obtained in all trials, the colonies of mites decreasing to small numbers and the plants developing normally without injury.

An extensive examination of dormant lily bulbs entering this country from Japan was made at Seattle, Wash. This examination showed every case of bulbs to contain live mites, and characteristic small feeding pits on the scales of all bulbs whether or not live mites were present. The infestation was universal but in most cases very light.

Tests were made to free the dormant bulbs of mites by the use of thermal treatments immediately before the bulbs were potted or forced. A 30-minute immersion in water at a temperature of 110 degrees F. or a 60-minute, vapor-heat treatment at the same temperature caused complete mortality, and apparently did not adversely affect the flowering.

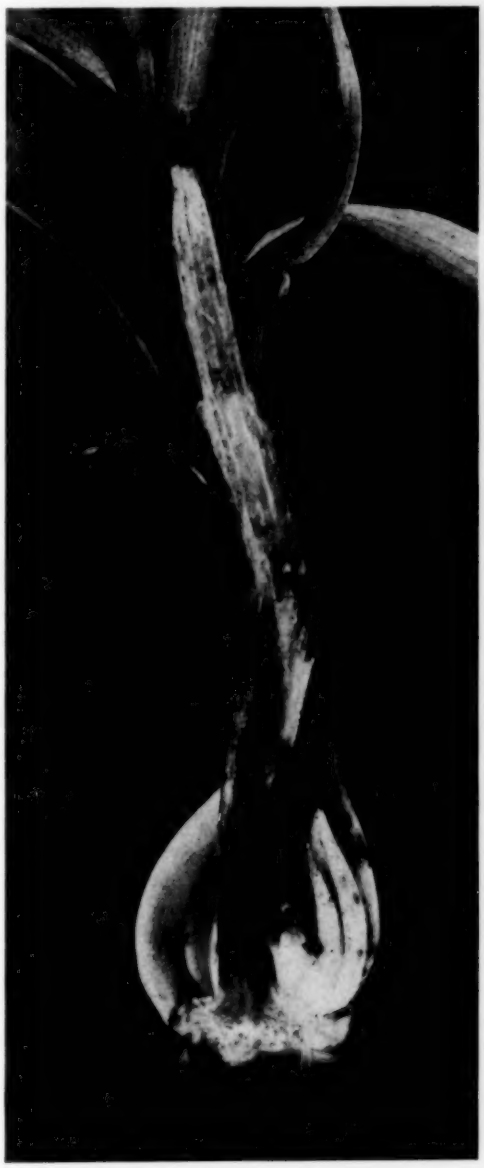

FIG. 1.—Midsection of stem and bulb of lily plant, showing severe mite injury to the stem. ×½.

* Acknowledgments are due to C. F. Doucette, under whose supervision this work was planned and carried out; to C. A. Weigel for records, material and helpful suggestions; and to various greenhouse operators near Tacoma and Seattle, Wash., who cooperated in these studies.

OBSERVATIONS IN COMMERCIAL GREENHOUSES.—Many thousand lily plants were examined in commercial greenhouses, both during active growing seasons and after flowers had been cut or the plants discarded, to bring about a better understanding of the relation of the mites to this host.

Every lot of lilies contained plants with stems injured by mites, but usually the proportion of injured stems was less than 5 per cent. Plants with external evidences of infestation in the stem were small or stunted, often affected with mosaic, and seldom appeared healthy or vigorous. Repeated observations determined *that there was a definite association between serious mite injury to the stems and a lack of development of the stem roots.* Bulbs injured by mites had few or no stem roots, and plants without stem roots were invariably injured by mites. An important factor in this association is that the area most favored by the mites as a point of feeding is the point of origin of the stem roots.

It was also observed that lily stems with normal brace roots were tough and fibrous, and difficult to break, whereas stems lacking roots were usually brittle and easily snapped.

Stems not having external symptoms of mite attack were often found to have characteristic discolored mite tunnels within them. These tunnels were not extensive enough to be injurious whenever the stem roots were normal, and they were untenanted. Apparently all feeding had ceased early in the stem development.

FIG. 2.—Plant lacking stem roots and having poor basal roots (left); normal plant (right). $\times\frac{1}{2}$.

The photographs† shown in figs. 1, 2, 3, 4 and 5 illustrate the principal observa-

† Attention is directed to the cover illustration of "Insects and Allied Pests of Plants Grown Under Glass," by E. I. McDaniel Mich. Ag. Exp. Sta. Bul. 214, 1931; and to figure 17, page 24, of "Insects Injurious to Ornamental Greenhouse Plants," by C. A. Weigel and E. R. Sasscer, U. S. Dept. Ag. Farmers' Bul. 1362, 1923, both of which show injured lily stems almost devoid of stem roots.

tions made. A mite injured stem with its associated lack of stem roots and a plant having normal roots are pictured in fig. 2. The lack of stem roots is also evident in figs. 1 and 5. The type of infested but uninjured stem which has a normal complement of stem roots is shown in fig. 3. The feeding on the scales was usually confined to the characteristic spotlike pits, fig. 4, except where there was a definite decay of portions of the scales, or where the outer scales were hollowed and almost entirely consumed by mites, fig. 5 The latter condition occurred on plants with normal stems and roots as well as on injured plants, but did not seem to advance internally from the outer scales. It has been suggested that these outer scales are natural discards of the bulb and that natural breakdown has preceded mite feeding.

Each year there are crop failures, in greenhouses where lily forcing is practiced, which are usually attributed to mite injury because numerous injured stems and populous colonies of mites are found. An examination in one such instance disclosed data as follows:

FIG. 3.—Normal plant in which early mite feeding (see arrows) apparently was stopped by vigorous production of stem roots. ×¼.

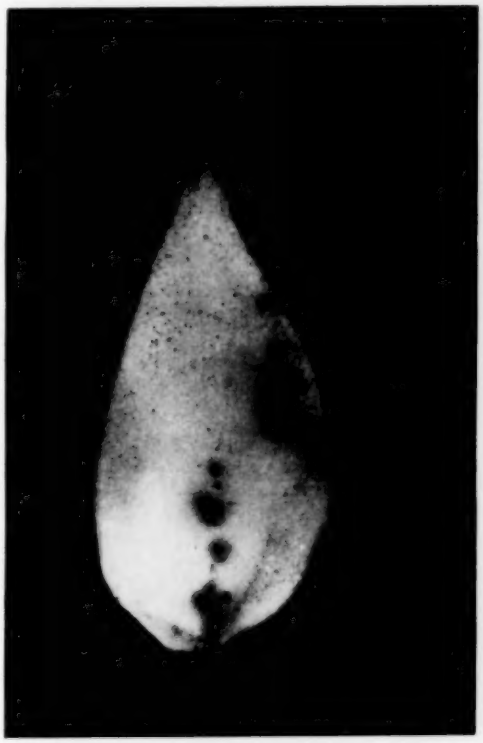

FIG. 4.—Scale of lily bulb with feeding pits. ×1

A lot of lilies of common origin and variety were decidedly subnormal, flowering about 30 to 40 per cent of normal expectation, and the flowers were of poor quality. Mite injury was externally evident on 80 of 555 plants. The entire lot, however, was characterized by poor condition of the basal roots; some were very feeble, whereas others apparently had developed normally but were browning or dying at the time of the plants' blooming. The brace roots were lacking on the 80 plants showing injured stems, and decidedly subnormal on the remainder.

DISCUSSION.—If it is considered that infestation of Easter lily bulbs by bulb mites is fairly universal—and the repeated requests for information and samples of infested or injured bulbs received each year by the Bureau of Entomology and Plant Quarantine and the florist trade journals substantiate the evidence of port inspection to this effect

FIG. 5.—Lily bulb with outer scales inhabited by bulb mites. ×½.

—it is apparent that there is some limiting factor besides the presence or absence of mites which holds injury in general to a small proportion of the total crop marketed yearly.

The association of subnormal stem roots and mite injury points strongly to an unknown plant disorder as being the forerunner of mite attack. Since the point of mite injury is also the point of origin of the stem roots, this disorder might be associated with the vascular system. Such an interpretation is not intended to challenge the fact that mites do attack stems and cause considerable damage when feeding extends beyond certain limits, but it does suggest that some unrecognized factor makes the stem region at the nose of the bulb particularly attractive so that it becomes the focal point of feeding and resultant injury. It further furnishes a logical explanation as to why crop loss is not more common since infestation apparently is universal, and why experimental trials failed to induce injury. There is added evidence in the preference of mites for seemingly unpalatable stems, fig. 1, rather than succulent scales, fig. 4, and in the brittleness of stems lacking roots.

On the other hand, it is as logical to assume that mite feeding causes the absence of stem roots. This assumption has considerable basis, both from the precedent of long acceptance and from lack of absolute proof otherwise. It is weakened, however, by the fact that stems lacking roots are unnatural and often brittle, and that injured plants are often suffering from some disorder of the entire root system.

Owing to the still undetermined status of this pest of lilies, it is considered that these facts are worth recording. When the foregoing interpretation is called to the attention of responsible persons who will have opportunity to investigate future complaints of serious mite injury, it may stimulate inquiry beyond ascertaining the presence of mite injury and corroborate the observations recorded here.

SUMMARY.—Experiments begun in 1935 failed to produce injury on Easter lily plants by bulb mite attack, even though such injury is often found in commercial practice. They also demonstrated that infestations of mites are probably present in all lots of Easter lily bulbs.

A definite association between mite injured stems and a lack of stem roots was found in observations of thousands of lily plants.

These observations may be interpreted as indicating that an unknown plant disorder is primary to mite injury on stems. —6-29-38.

Toxicity to the Codling Moth Larva of Derivatives of Benzene Containing Halogen and Nitro Groups

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In the search for organic compounds which might replace the arsenicals now commonly employed for the control of the codling moth, *Carpocapsa pomonella* L., p-iodonitrobenzene was found by Smith, Siegler & Munger (1936) to have high initial toxicity. As a result of the effectiveness of this compound a study has been made of the toxicity of the halogenated benzenes, nitrobenzene and the three isomeric monohalogenated nitrobenzenes, dihalogenated (except difluoro) benzenes and dinitrobenzenes.

Although circumstances did not permit a study of the listed compounds under a uniform set of conditions, it is believed that the results obtained, as shown in tables 1 and 2, will be of general interest to those engaged in insecticide investigations.

Table 1.—Results of tests of halogenated benzenes, nitrobenzene, monohalogenated nitrobenzenes dihalogenated benzenes (except difluoro) and dinitrobenzenes against the codling moth larva.

Compound	Carrier	Number of Plugs	Apple Plugs Wormy, Per Cent	Apple Plugs Stung, Per Cent	Standard Error of Per Cent Wormy
Fluorobenzene	*	48	89.6	0.0	±7.13
Chlorobenzene	†	51	80.4	15.7	±7.13
Bromobenzene	†	50	84.0	12.0	±7.13
Iodobenzene	†	33	100.0	0.0	±3.15
Nitrobenzene	†	48	98.0	0.0	±3.15
o-Fluoronitrobenzene	‡	47	95.8	2.1	±2.88
m-Fluoronitrobenzene	†	52	86.5	7.7	±7.13
p-Fluoronitrobenzene	†	97	91.8	4.1	±2.03
o-Chloronitrobenzene	†	86	93.0	2.3	±2.12
m-Chloronitrobenzene	†	95	98.9	0.0	±2.03
p-Chloronitrobenzene	†	188	76.6	20.2	±3.09
o-Bromonitrobenzene	†	138	92.0	5.1	±1.70
m-Bromonitrobenzene	†	94	84.0	1.1	±5.02
p-Bromonitrobenzene	†	139	27.3	41.0	±4.59
o-Iodonitrobenzene	†	99	54.6	42.4	±4.91
m-Iodonitrobenzene	†	48	16.7	6.2	±5.49
p-Iodonitrobenzene	†	91	0.0	56.0	—
o-Dichlorobenzene	†	42	100.0	0.0	±3.15
m-Dichlorobenzene	†	42	97.6	0.0	±2.88
p-Dichlorobenzene	†	41	100.0	0.0	±3.15
o-Dibromobenzene	‡	40	92.5	0.0	±2.88
m-Dibromobenzene	‡	38	81.6	0.0	±7.13
p-Dibromobenzene	†	80	100.0	0.0	±2.12
o-Diiodobenzene	‡	43	81.4	2.3	±7.13
m-Diiodobenzene	‡	44	86.4	0.0	±7.13
p-Diiodobenzene	†	99	97.0	1.0	±2.03
o-Dinitrobenzene	†	45	100.0	0.0	±2.88
m-Dinitrobenzene	†	74	39.2	14.9	±7.01
p-Dinitrobenzene	†	89	94.4	3.4	±2.12
Lead arsenate	†	102	31.5	25.5	±5.73
Check (unsprayed)—Washington state larvae	—	667	95.8	0.8	±0.78
Check (unsprayed)—Local larvae	—	308	98.0	1.0	±0.85

* 1 lb. of casein-ammonia (1 per cent solution) to 50 gallons of a mixture of water 80 per cent +95 per cent ethyl alcohol 20 per cent.
† Water 80 per cent +95 per cent ethyl alcohol 20 per cent.
‡ Water 99 per cent +95 per cent ethyl alcohol 1 per cent.

Table 2.—Results of initial and residual tests of p-iodonitrobenzene against the codling moth larva.

Spray Materials	Dosage, Lbs. Per 100 Gals. Water	Days After Spraying When Plugs Were Infested	Number of Plugs	Apple Plugs Wormy, Per Cent	Apple Plugs Stung, Per Cent	Standard Error of Per Cent Wormy
p-Iodonitrobenzene Casein-ammonia (1% soln.)	4 2	1	96	0.0	44.8	—
p-Iodonitrobenzene Casein-ammonia (1% soln.)	4 2	6	89	87.6	4.5	±2.81
p-Iodonitrobenzene Soybean flour	4 1	1	38	0.0	55.3	—
p-Iodonitrobenzene Soybean flour	4 1	6	39	62.0	2.6	±8.61
p-Iodonitrobenzene	4	0	79	0.0	31.6	—
p-Iodonitrobenzene	4	5	74	54.1	2.7	±8.90
Lead arsenate	4*	0	215	16.3	6.0	±2.80
Lead arsenate	4*	7	212	17.0	16.0	±2.80

* Carrier = Water 80 per cent + 95 per cent ethyl alcohol 20 per cent.

All the tests were made at a dosage of 4 pounds of the organic compound to 100 gallons of the carrier by means of the apple-plug method, one larva being used to a plug. Two strains of larvae, namely, Washington state and local (Virginia and West Virginia), were used, and, as will be noted by referring to the unsprayed tests, the two strains appear to be substantially alike with respect to percentage of larval entrants. As in the previous experience of the writers, it has again been found difficult to obtain uniformity of suspension of the different compounds. Because of the variation in the physical properties of the organic compounds reported in this paper, a special study of dispersing agents would be required in order to insure the best results obtainable. Since this has not been done, the reader should consider the results in this paper as indicating only the approximate toxicity.

The standard errors of the means* for the compounds giving 90.1–100.0 and 80.1–90.0 per cent survival were computed from estimates of the standard deviation derived from analyses of variance for these two groups. In the tests of the organic compounds, each mean is based on a series of from 5 to 23 tests, from 2 to 11 apple plugs being used in each. In the tests with unsprayed plugs, there were for Washington state larvae 84 tests of from 3 to 10 plugs each and for local larvae 33 tests of from 7 to 10 plugs each. The analyses showed no significant variation among compounds within the groups. Although the use of this generalized standard deviation involved ascribing an error to the compounds, which in several trials gave 100 per cent survival, it is believed the survival of 100 per cent is due to an accident of sampling. In any event, the generalized standard deviation is more representative than a series of standard deviations, one from each compound.

In the other survival groups (within a range of 10 per cent), only one compound occurred in a group. For this reason no analysis was made and the standard error was computed in the ordinary way.

It will be noted from table 1 that the monohalogenated benzenes and nitrobenzene show little toxicity to the codling moth larva.

The three isomeric fluoronitrobenzenes were nontoxic, and no significant differences between the three were observed.

The same is substantially true with regard to the chloronitrobenzenes. However, in the bromonitrobenzene series the para derivative is more toxic than the ortho or the meta compound.

All the iodonitrobenzene compounds proved to be toxic. Judged from the percentage of wormy fruit, the ortho compound was the least toxic, the meta more toxic and the para compound most toxic.

* The authors are indebted to F. M. Wadley, U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine, for his assistance.

There is apparently no significant difference between the isomeric dihalogenated benzenes with respect to toxicity. None is appreciably toxic. Possibly, however, more extensive tests would show that the toxicity increases with the molecular weight.

Of the dinitrobenzenes the metadinitro isomer is much more toxic than either of the other two.

The results of tests with unsprayed fruit are also given in table 1.

Further tests of p-iodonitrobenzene were made to determine the residual effectiveness of this compound. As shown in table 2, all the larvae were killed when the apple plugs were infested one day or less after the spray had been applied. The percentage of stung fruit, however, was high. On the other hand, in the tests in which the plugs were infested from five to six days after spraying, the effectiveness of p-iodonitrobenzene was of a considerably lower order. The stung fruit in the tests of freshly applied spray appear as wormy fruit in the residual tests.

SUMMARY.—Among several benzene derivatives tested against codling moth larvae, p-iodonitrobenzene, m-iodonitrobenzene, p-bromonitrobenzene and m-dinitrobenzene gave an initial toxicity of less than 50 per cent of wormy plugs. In residual tests p-iodonitrobenzene lost most of its effectiveness in five or six days.

The data obtained indicate no marked correlation between either the groupings involved or their relative position, with regard to their toxicity to the codling moth larva.—7-2-38.

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Plant Breeding and Selecting for Insect Resistance

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The biological control of insects as related to host resistance is a relatively new field of study in which recent development has been rapid. Many insects, especially species that attack field crops which are produced on marginal land, cannot be economically controlled by the use of insecticides. Therefore it is necessary to seek other means. In many cases the most feasible method of control seems to lie in the development of resistant varieties of plants.

Ordinarily when we speak of resistance we refer to instances in which the plant's normal growth is damaged but little by insects. This is different from apparent resistance found in the plant which escapes injury because of earliness. The kind of resistance should be determined, because under some conditions the apparently resistant variety will be planted late with disastrous results. It must be remembered also that usually resistance is relative and not absolute, the degree being dependent on the level of insect abundance.

In order that the best progress may be made in a study of insect resistance, the thorough cooperation of entomologists, plant breeders and agronomists is necessary. The entomologists should determine the degree of insect infestation on different varieties, strains and hybrids, study the reaction of the insect to these varieties from the standpoint of their effect on the insect's biology and its preferential selection of hosts, and determine the value of resistant strains in actually bringing about economic control of the insect. The plant breeder and agronomist should secure new strains of crop plants for testing, making crosses and growing hybrids, and should study the agronomic quality and characters of the hybrids and strains.

One of the difficulties often encountered in insect resistance studies is the lack of a sufficient insect infestation every year. It is especially desirable, when testing segregating generations (from the second to the sixth generation), to have a suffi-

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cient population to produce clear-cut varietal differences in reaction. It is through results observed in these generations that one must discard or select, and it usually is impossible to identify insect resistant plants except in the presence of insects. It is possible in some cases to secure artificial infestation. In hessian fly studies, infested stubble is often placed in the alleyways between plats. In chinch bug studies, barley, which is the chinch bug's favorite small grain host, is often planted in the alleyways early enough to attract the bugs when they are migrating from winter quarters. When the barley is harvested, they migrate into the corn or sorghum nursery. Often it is difficult to secure a uniform infestation throughout the nursery, and this is especially true with insects that do not fly.

DISCOVERING RESISTANT VARIETIES.—In the study of insect resistance, one must adopt a different method of procedure for each crop and for each insect, but the development of resistant varieties in general is somewhat similar. First, one must test many varieties and strains, and it may be necessary to include those possessing inferior agronomic qualities if satisfactory resistance is not found among those considered suitable from an agronomic standpoint. One must not only notice the effect of the insect on the variety as a whole, but on individual plants within the variety. For example, in the spring of 1934, during a very severe outbreak of the pea aphid in Kansas, Painter & Grandfield (1935) found in some fields solitary plants that were green and succulent surrounded by plants that had been killed by the aphids. Blanchard & Dudley (1934) found individual plants of alfalfa on which the pea aphid was unable to maintain a population. Seed was saved from these resistant plants and this may serve as a start for a new pea aphid resistant strain of alfalfa. Often even these individual resistant plants are not homozygous for characters that have to do with resistance, and therefore pedigree selections must be made from them.

Varieties of plants that are apparently homozygous for agronomic characters, but which have never been subjected to insect injury, have been shown to be heterozygous for the genetic factors governing resistance or susceptibility when grown in the presence of insects. A good example of this was reported by Snelling *et al.* (1937) at the Lawton, Okla., experiment station with the sorghum variety *Chiltex* This variety was apparently homozygous for agronomic characters but previous to 1932 it had never been subjected to serious chinch bug injury. It was grown in 1932 at Lawton under a heavy chinch bug infestation and only a few heads produced grain. This seed was saved and planted in 1933 adjacent to rows planted from the original seed that had never been subjected to natural selection by chinch bugs. In 1933, 53.1 per cent of the plants of *Chiltex* as introduced to Lawton were killed, while only 22.6 per cent of the plants of *Chiltex* strain from seed grown in 1932 were killed. This experiment was repeated under a very heavy infestation in 1934 and all the plants of the original *Chiltex* were killed, whereas only 68.0 per cent of the Lawton selection was killed. The Lawton selection of *Chiltex* is apparently unchanged from the original type with respect to agronomic characters, and so far as known cannot be distinguished from the original *Chiltex* except when grown in the presence of chinch bugs. Several other similar cases with sorghums could be cited.

THE BREEDING PROGRAM.—It will be very unusual if the resistant strain or variety selected possesses all the desired agronomic characters. If it does not, it is then time to start the breeding program. Plants from the variety having insect resistance should be crossed with plants from a variety having the desired agronomic characters. Results in such a breeding program cannot be expected in two or three years, because after the cross is made segregation will take place for five or six generations. Even after a homozygous type has been obtained, it is necessary to test it in nursery rows, field plats and regional experimental fields before the variety can be distributed to farmers. Before the variety can be put out on farms, it may be desirable that it be tested for plant disease resistance and other factors of the crop.

If the infestation of the insect is sufficiently heavy, the process of selection during the segregating period is relatively easy, because frequently all the inferior insect susceptible types are killed by the insects before seed is formed. During the segregating period it is advisable to save

the seed from those plants which show a high degree of insect resistance, even though they may be inferior in agronomic quality, because these plants may be used later as insect resistant parents in another breeding program.

The desirability of this procedure was shown in the chinch bug sorghum nursery at Manhattan, Kan., in 1924 (Snelling *et al.* 1937), where many F_5 lines of the cross Kansas Orange×Dwarf Yellow milo were planted; chinch bugs killed all but a single plant. Seed was saved from this plant and developed into the strain known as KS No. 24-136, which is the most resistant to the chinch bug of any strain of sorghum known. However, it has never been distributed to farmers because of its inferior agronomic qualities. It has, however, been used in our breeding program, where it serves as a storehouse of genes for chinch bug resistance in sorghums.

The great forward step in the breeding program occurs when transgressive segregation appears. This is when segregates more resistant than either parent are obtained from a cross. Such segregates often occur, but usually they are few in number and so may be overlooked, or they may not contain the desirable agronomic character.

There is some indication that workers with insect resistance may run into the same trouble that the plant pathologist has encountered in working with plant disease resistance; that is, there may be various biological forms within the species, even though these forms may be indistinguishable to the taxonomist. The variety that the investigator thinks is resistant may not be resistant to all strains of the insect. There is considerable proof that there are at least two strains of the hessian fly (Painter *et al.* 1931).

The investigator should not be too greatly discouraged by this fact because a variety resistant to one major insect pest in one locality is of some practical value.

There still remain some investigators who are not convinced that insect resistance is inherited. The data that have been obtained on chinch bug resistance of sorghum hybrids in advanced generations at Lawton indicate very clearly that resistance to chinch bug injury in sorghums is inherited (Snelling *et al.* 1937). Among the selections from the cross Kansas Orange×Dwarf Yellow milo, KS 30-33, a combine type of grain sorghum, showed more resistance than the susceptible milo plant, but less resistance than the resistant Kansas Orange parent. Another selection from the same cross, KS 24-136, showed transgressive segregation and in each year tested was more resistant than the resistant Kansas Orange parent. The studies of these hybrid selections indicate that resistance to chinch bugs is inherited independently of agronomic characters. Studies of resistance to the hessian fly in wheat (Painter *et al.* 1931) also show very clearly that resistance is an inherited character. Some hybrid selections from resistant and susceptible crosses are about as resistant as the resistant parent, others are as susceptible as the susceptible parent, and still others are intermediate.

While it has been shown in several cases that insect resistance is inherited, in most cases the number of genetic factors involved in such resistance has not been conclusively shown. Cartwright & Wiebe (1936), working under California conditions, showed that resistance to the hessian fly in the wheat crosses Dawson× Poso and Dawson×Big Club is heritable and that it is controlled by two genetic factors.

CAUSE OF INSECT RESISTANCE.—The cause of insect resistance in plants is a very complex problem and much more research is needed to determine it. In most cases, no visible morphological or physiological characters seem to be correlated with resistance. Little is known as to how the genetic factors operate to produce resistance or susceptibility in plants. Studies with varieties of sorghum resistant and susceptible to the chinch bug (Dahms *et al.* 1936) have shown that more bugs are attracted to a susceptible variety than to one that is resistant; therefore, under field conditions such a variety may receive a larger population of adults that are migrating by flight. Furthermore, the bugs live longer and lay more eggs, and the nymphs develop faster and more of them reach maturity on a susceptible variety than on a resistant one. These are factors that tend to increase still more the bug population on susceptible varieties. Under laboratory conditions when different varieties of sorghums are exposed to a uniform infestation of chinch bugs, the susceptible varieties are always the first to be killed.

SUMMARY.—The control of insects by the use of resistant varieties is a relatively new field and seems to be the most feasible method of controlling insects on some plants. For best results, the problem requires the cooperation of entomologist, plant breeder and agronomist. Heavy uniform infestation by the insect is desirable, but often difficult to secure in resistance studies. Insect resistance in many cases is known to be an inherited character. By proper selection, insect resistant varieties are often obtained, but these usually must be crossed with other varieties before resistant varieties possessing desirable agronomic characters are secured. Development of resistant varieties by breeding is a very slow process, often requiring as long as 10 years. It is possible that there may be more than one strain of an insect, and that a variety which is resistant to one strain may not be resistant to another. The cause of insect resistance in plants is very complex and in some cases is known to influence the biology of the insect itself.—7-7-38.

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Control of the Flatheaded Apple Tree Borer in Oklahoma

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On the basis of these tests, if lead arsenate is to be used as a spray for killing the adults it should be applied at the rate of 6 pounds per 50 gallons of water. The practicability of controlling the adults with a stomach poison is not proved, however. Field studies show the beetles to be exceedingly active in running about over the branches and main trunks of trees and in flying from tree to tree. Even if all the trees in an orchard were sprayed it would not prevent beetles from flying in and ovipositing on the trees.

REPELLENT PAINT FORMULAS TESTED.—A list of the repellents used is presented here to eliminate repetition since some of them are used in several types of tests. There were 16 preparations tested as repellents to prevent oviposition by the female beetles. Several of these paints were used also in cage tests to determine their effect in preventing the beetles from resting on treated cuttings. All were applied with a brush.

Repellent No. 1.—Heat 50 pounds of potash fish-oil soap and 3 gallons of water to 180 degrees F. and mix well. Slowly stir in 2 pounds of flour. The flour mixes better if first stirred up separately with part of the water. Add 25 pounds of naphthalene while holding at 180 degrees F. (melting point of naphthalene is 176 degrees F.) and stir thoroughly until it is dissolved. Chill as quickly as possible while stirring occasionally. Quick cooling tends to make the naphthalene crystals smaller. This formula is the same as that recommended by Pettit (1923) except potash fish-oil soap is used here instead of potash soap.

During 1937 further experiments on the control of the flatheaded apple tree borer, *Chrysobothris femorata* (Oliv.), were carried out near Stillwater, Okla. These consisted of cage toxicity studies, field and laboratory tests with repellent paints, field tests with fumigant paints and tree wraps.

* Submitted by the senior author in partial fulfillment of the requirements for the Degree of Master of Science in Entomology in the Graduate School of the Oklahoma Agricultural and Mechanical College, Stillwater, May, 1938.

TOXICITY STUDIES.—Laboratory studies to determine the possibility of killing the beetles with poisonous sprays were conducted in cylindrical 16-mesh wire screen cages about 12 inches in diameter and 24 inches high. Each cage was placed over two or three apple branches inclosed in a 4-ounce, wide-mouth bottle set in the soil so that it would not tip over. The bottles were kept full of water to keep the branches in a fresh condition. Since the adults feed on bark and phloem tissue from the spurs and crotches of one- or two-year old wood, this type of branch was used in the cages. The poisons were applied in liquid form with a paint brush. Fresh branches were used whenever a new cage was installed for further tests. Beetles were placed in the cages the same day they were taken from the emergence cages. Observations were made and recorded daily. Cages were run for eight days unless the beetles in the treated cages were all dead before that time. All tests were conducted under greenhouse conditions.

Lead arsenate was used at concentrations of 2, 4, 6, 8, 10 and 12 pounds per 50 gallons of water. Derris at 2 pounds per 100 gallons of water was used with casein as a sticker. Two and one-half pounds of sodium arsenate and 5 quarts of summer spray oil (*Verdol*) per 50 gallons of water, and 5 pounds of sodium arsenate and 5 quarts of *Verdol* per 50 gallons of water were also tested.

Table 1.—Toxicity tests on cage emerged *Chrysobothris femorata* adults, Stillwater, Okla., 1937.

No.	Date	Treatment	Number Beetles	Per Cent Mortality on Successive Days								Total Number Dead	Total Per Cent Dead
				1	2	3	4	5	6	7	8		
1	June 7	Lead arsenate 2–50	37	13.5	37.8	51.4	70.3	83.8	86.5	86.5	91.9	34	91.9
2	9	Lead arsenate 4–50	20	15.0	35.0	65.0	85.0	100.0	—	—	—	20	100.0
3	10	Lead arsenate 6–50	17	29.4	88.2	100.0	—	—	—	—	—	17	100.0
4	12	Lead arsenate 8–50	24	12.5	54.2	87.5	100.0	—	—	—	—	24	100.0
5	13	Lead arsenate 10–50	25	8.0	32.0	72.0	96.0	100.0	—	—	—	25	100.0
6	15	Lead arsenate 12–50	9	0.0	44.4	100.0	—	—	—	—	—	9	100.0
7	14	Derris (5% Rotenone) 2–100 (Casein spreader)	14	7.1	28.6	42.9	92.9	100.0	—	—	—	14	100.0
8	11	Sodium arsenate 2½–50 *Verdol*—5 qt.	37	10.8	40.5	81.1	94.6	100.0	—	—	—	37	100.0
9	14	Sodium arsenate 5–50 *Verdol*—5 qt.	14	21.4	35.7	71.4	100.0	—	—	—	—	14	100.0
		All checks	185	4.9	17.3	34.6	43.8	48.0	48.6	50.3	50.8	94	50.8

Table 1 presents the data obtained. While it is felt that the results are inconclusive because of the small number of beetles used, the figures for lead arsenate are interesting. They show that at all strengths the mortality was greater in the treated cages than in the checks, and this was especially noticeable at strengths used above 2 pounds of the lead arsenate per 50 gallons of water. There is a trend

which appears to show a repellent effect of lead arsenate when used at strengths above 6 pounds per 50 gallons of water.

Repellent No. 2.—Mix 5 pounds of washing soda and 3 quarts of potash fish-oil soap with water to make 6 gallons. Add hydrated lime to the consistency of thick paint. To this add 3 teaspoonfuls of Paris green and 1 ounce of carbolic acid and mix thoroughly. This formula is the same as that used by Fletcher (1895) for peach bark borer control except that he used a soft soap, air slaked lime and 3 tablespoonfuls instead of 3 teaspoonfuls of Paris green.

Repellent No. 3.—Slake one-half bushel of rock lime with water and while it is still hot add 3 pounds of rice boiled to a thin paste and 2 quarts of rock salt previously dissolved in a little warm water. Sift 2 pounds of powdered casein slowly into the cool whitewash. Sift in 2 pounds of naphthalene flakes and add water to a thick wash. Lovett (1923) lists this wash as being particularly effective against the flatheaded borers.

Repellent No. 4.—Thoroughly mix 1 pound of potash fish-oil soap and 1 pint of carbolineum avenarius; then add 1 quart of water.

Repellent No. 5.—Dissolve 1 pound of sodium carbonate in 1 quart of hot water, add 1 quart of carbolineum avenarius and stir vigorously until the mixture is emulsified. Dilute with 2 quarts of water when the repellent is used. A bucket spray pump aids in the emulsification of the stock. This paint was used by Matheson (1917) in his work on the poplar and willow borer.

Repellent No. 6.—Liquefy 4 pounds of paraffin in a double boiler, add 1 pound of paradichlorobenzene, and stir until the mixture is dissolved. Apply the repellent while it is in a melted state. Gilbertson (1934) used this wash against the plum tree borer.

Repellent No. 7.—Add 9 parts of ethylene dichloride to 1 part of dilute potash fish-oil soap (30 per cent soap and 70 per cent water) and emulsify by agitation to make a stock emulsion. This was used at a dilution of 1 part stock to 4 parts water, giving a 20 per cent ethylene dichloride emulsion. Snapp & Thomson (1936) found this preparation very effective in the control of the peach borer. While it is primarily a fumigant, it was tried both as a repellent and a fumigant in this work.

Repellent No. 8.—Mix 1 pint of carbolineum americanus and 1 pound of potash fish-oil soap, and add 1 quart of water.

Repellent No. 9.—Mix 1 part of liquid lime sulfur with 7 parts of water and make these into a thick wash by the addition of hydrated lime. Guyton & Knull (1924) used this paint to repel the roundheaded apple tree borer.

Repellent No. 10 (Lovett 1923).—Dissolve one-fourth pound of copper sulfate crystals in a small amount of water and add to 8 pounds of quick lime while it is slaking. Add one-half pound of casein, 1 pound of naphthalene flakes, and water to form a thick wash as in repellent no. 3.

Repellent No. 11 (Lovett 1923).—Make similar to repellent no. 3 except substitute crude carbolic acid in place of the naphthalene flakes. Use the carbolic acid at the rate of one-half pint per 6 gallons of dilute wash.

Repellent No. 12.—Full strength creosote. Matheson (1917) reported this wash as giving good control of the poplar and willow borer.

Repellent No. 13.—Paraffin applied while liquefied.

Repellent No. 14.—Paraffin and paradichlorobenzene at one-half the strength of repellent no. 6.

Repellent No. 15.—Three gallons of water, 1 gallon of potash fish-oil soap and one-half pint of crude carbolic acid mixed thoroughly. Lovett (1923) lists this preparation against the shot-hole borer.

Repellent No. 18.—Same as repellent no. 5 except used without dilution.

CAGE TESTS OF REPELLENT PAINTS.—Cages of 16-mesh screen on a wood framework $2\frac{1}{2}$ by $2\frac{1}{2}$ by $2\frac{1}{2}$ feet in dimension were used in these tests. A door was built in the bottom half of one side to facilitate the placing of material in the cage. No bottom was needed since the cages were placed directly on the ground. Apple cuttings from $1\frac{1}{2}$ to 3 inches in diameter and about $2\frac{1}{2}$ feet long were used in the cages. Two painted cuttings, one of larger diameter and one of smaller diameter, were placed in jars of water set in the soil for support in opposite corners of the cage, while two similar unpainted cuttings were placed in the other two corners. Observations on the number of beetles on both painted and unpainted wood were made and recorded at 9 and 11

a.m. and 1, 3 and 5 p.m. daily. The number of adults per cage varied from 30, in most cases, to 73. Beetles from hibernation cages and from field collections were used in separate cages the same day they were removed or collected.

Table 2 presents the data secured by using beetles from hibernation cages. The test on repellent no. 1 showed practically as many on the treated cuttings as on the checks. Repellent no. 9, a white colored paint, seemed to attract the beetles; this finding agrees with the field observation that the adults were apparently attracted to white objects such as clothing and would alight on them more often than on dark things. Treatments 5 and 18, both carbolineum preparations, show a marked repellence to the beetle and agree well in results. However, it is felt that care should be taken in drawing conclusions from these data. It was noted in these tests as in those with stomach poisons that the beetles were very restive in the cages. They ran rapidly around over the cage or flew across it and seemed to be trying to get away. Field collected adults were tested in the same way, but no results were obtained. They behaved in a manner similar to the beetles emerged from the cages but in addition they died soon; all were dead by the end of the second day after the test was started. Thus, the same possibilities were encountered as under the toxicity test setup. Either this insect is unsuited to cage testing or a suitable method was not employed.

Table 2.—Effect of repellent paints on *Chrysobothris femorata* adults in cages, Stillwater, Okla., 1937.

Repellent No.	Date of Test	Number of Beetles Used in Test	Number of Readings	Number of Beetles Observed		Per Cent of Beetles Observed	
				On Treated Wood	On Check	On Treated Wood	On Check
1	June 3 to 23	?	95	574	596	49.1	50.9
5	June 7 to 12	?	25	7	51	12.1	87.9
9	June 14 to 19	30	26	120	85	58.5	41.5
18	June 12 to 19	73	33	31	165	15.8	84.2

Repellent Paints on Growing Trees.—Many of a group of 84 young apple trees which had been set out the spring of 1937 were treated with several repellent paints. Some of the trees were treated June 23 and the remainder July 2. Thirty-five trees were left untreated. All were examined for borers late in July when it was found that the treated trees varied somewhat from an average of five borers per tree while the checks averaged four borers per tree. Since the treatments were applied after oviposition had probably been going on for some time,† it is felt that the results do not give a true picture of the effect of the paints on repellence.

One point brought out by this test deserves note. While 13 of the 35 untreated trees, or 37 per cent, contained from one to four parasitized larvae, only two of the 49 treated trees, or 4 per cent, contained one parasitized larva each. These preparations, namely nos. 1, 3, 4 and 5 of the repellent paints, appear to protect the borers from being parasitized, a situation that may or may not, but probably does, hold true for most preparations.

Repellent Paints on Cuttings.—After it was found that cage tests were not giving satisfactory results, a plan for testing repellent preparations under field conditions was devised. Several trees about 20 feet tall and poorly foliated or weakened by previous borer attack were located in the horticultural pecan grove. These trees were being frequented by the adult borers. Quart oil cans with the tops cut out were washed and fastened to exposed limbs of the selected trees. Black walnut and apple cuttings about 30 inches long and 1 to 3 inches in diameter were selected from borer free material. Several cuttings of both kinds were painted with each of the repellent mixtures to be tested and were then fastened in the cans in the

† Maxwell & Fenton, 1937, found a preoviposition period of about six days in cage studies. Since the peak of cage emergence was June 12, assuming that field emergence roughly corresponded, the authors believe that oviposition had been in progress some time before the trees were painted.

trees with pieces of twine. The cans were filled with water to help keep the wood from drying out. Exposure was for three days during the first part of July when the borer population was high and for five to seven days when the population had fallen off later in the season.

After being exposed in the trees, the cuttings were taken in and those treated with the same preparation were put together in five-quart tin cans kept filled with water. After 20 to 25 days, the exposed material was examined for borers by having the bark cut off with a knife. Any borers present were large enough at this time to be easily seen.

At the time of examining the cuttings for borers it was noted that several of the preparations were injurious to the bark. Repellent no. 12, full strength creosote, was very injurious. No. 6, containing paradichlorobenzene, was somewhat injurious, while no. 14, containing one-half as much paradichlorobenzene as no. 6, was less harmful. Material no. 2, which contained carbolic acid and Paris green was a little injurious to the bark, while preparations no. 11 and 15 which contained more carbolic acid than no. 2, but no Paris green, only very slightly affected the bark.

Table 3.—Infestation by *Chrysobothris femorata* of treated apple and walnut cuttings exposed to field conditions, Stillwater, Okla., 1937.

Formula No.	Date Series		Apple Cuttings					Walnut Cuttings				
	Began	Closed	Number of Cuttings	Total Total Number of Borers	Number Borers Per Cutting	Number Less Than Check	Per Cent Less Than Check	Number of Cuttings	Total Number of Borers	Number Borers Per Cutting	Number Less Than Check	Per Cent Less Than Check
1	July 3	July 15	26	102	3.9	2.6	40.0	20	76	3.8	16.9	81.6
2	July 3	July 15	25	142	5.7	0.8	12.3	23	433	19.7	1.0	4.8
3	July 3	July 15	25	142	5.7	0.8	12.3	22	41	1.9	18.8	90.8
4	July 3	July 15	25	71	2.8	3.7	56.9	22	11	0.5	20.2	97.6
5	July 3	July 15	25	66	2.6	3.9	60.0	20	105	5.3	15.4	74.4
Checks Comparable to 1, 2, 3, 4, 5			42	272	6.5	—	—	36	745	20.7	—	—
6	July 3	July 19	23	8	0.3	5.8	95.1	20	81	4.0	15.7	79.7
Checks Comparable to 6			45	274	6.1	—	—	41	806	19.7	—	—
7	July 5	July 10										
	Aug. 9	Aug. 11	19	40	2.1	3.3	61.1	16	122	7.6	2.8	26.9
Checks Comparable to 7			32	172	5.4	—	—	28	291	10.4	—	—
8	July 12	Aug. 4	26	76	2.9	0.6	17.1	26	29	1.1	24.2	95.6
Checks Comparable to 8			43	151	3.5	—	—	44	1,112	25.3	—	—
9	July 19	Aug. 11	24	39	1.6	0.4	20.0	24	67	2.8	17.2	90.5
10	July 19	Aug. 11	24	27	1.1	0.9	45.0	24	162	6.7	12.3	64.7
11	July 19	Aug. 11	24	44	1.8	0.2	10.0	24	181	7.5	11.5	60.5
13	July 19	Aug. 11	24	17	0.7	1.3	65.0	24	56	2.3	16.7	87.9
Checks Comparable to 9, 10, 11, 13			39	78	2.0	—	—	40	739	19.0	—	—
12	July 19	July 26	10	6	0.6	2.2	78.6	10	0	0.0	29.5	100.0
Checks Comparable to 12.			15	42	2.8	—	—	17	501	29.5	—	—
14	Aug. 2	Aug. 11	12	0	0.0	1.5	100.0	12	12	1.0	8.2	89.1
15	Aug. 2	Aug. 11	12	21	1.7	−0.2	−13.3	12	15	1.2	8.0	86.9
Checks Comparable to 14, 15			18	27	1.5	—	—	18	166	9.2	—	—

The results of cutting examinations for borers is presented in table 3.

It should be noted that the untreated walnut cuttings were much more heavily infested than the untreated apples. The walnut bark is probably more attractive to the female beetles as a place for oviposition because of its rougher character.

The effectiveness of the materials used

is measured by the per cent fewer borers per cutting than in comparable checks. It is seen that in most cases the same paint differs considerably in per cent reduction of borers in apple and walnut. This difference is probably caused by the fairly small number of cuttings treated with each preparation. However, it might be possible that one repellent would be more effective on apple than on some other kind of wood while the reverse could be true of some other preparation. Since this study was more or less of a preliminary nature as a basis for further work it was thought wise to test as many preparations as possible in an effort to eliminate ineffective or injurious materials.

It is seen that in general the repellents gave a greater reduction in borers in the walnut than in the apple. It is felt that this is due to the paint causing a greater change in the physical character of the surface in the case of walnut. The paints applied to the walnut bark make it smoother than the untreated cuttings and less attractive comparatively than apple cuttings.

Paint no. 12, full strength creosote, gave good results, especially on walnut, but could not be used as a control because of its injurious effect on the wood. Possibly it could be prepared in the form of an emulsion which would give good results without injury.

Preparations 2, 11 and 15 contained carbolic acid and were more or less injurious as noted above; also they were in general ineffective with the exception of no. 15 on walnut. No. 15 on apple, however, resulted in more borers than the comparable checks.

Nos. 6 and 14, containing paraffin and paradichlorobenzene were effective but also injurious. When these repellents are compared with no. 13, paraffin only, it is seen that their effectiveness is probably due largely to the paraffin and not to the paradichlorobenzene.

Preparations containing naphthalene, namely nos. 1, 3 and 10, were very effective on walnut but only moderately effective on apple.

Repellents containing lime to make a thick wash tend to scale or shell off easily, especially on the smoother bark of the apple cuttings. This might help account for the fact that paints 2, 3, 9, 10 and 11 showed fairly low repellence on apple. Because of this possibility, of the preparations containing naphthalene, no. 1 would be the most desirable.

It is felt that paint no. 7 would not be an effective repellent because ethylene dichloride is very volatile and would not have any lasting quality. Further consideration is given this material in fumigant tests in the next section.

No. 4 carbolineum avenarius and potash fish-oil soap, gave better results than no. 5, carbolineum avenarius and sodium carbonate. But no. 5 is a more lasting preparation. It would not wash off by rain so easily as those preparations containing soap as an ingredient.

Material no. 8, the same as no. 4 except for the substitution of carbolineum americanus for carbolineum avenarius, appeared slightly inferior to no. 4.

From the standpoint of lack of injury to the wood, effectiveness of repellence and lasting quality, it is believed that the carbolineum avenarius and sodium carbonate mixture is superior.

This study reveals that preparations which merit further investigation as repellents, excluding those that are more or less injurious, are nos. 1, 5, 13 and possibly 4. The potash fish-oil soap and flour mixture of no. 1 seems to give the preparation a more durable quality than soap alone.

TESTS WITH FUMIGANT PAINTS.—Four preparations were tried as fumigants to kill the borers while in the larval stage under the bark. These were as follows:

Fumigant No. 7.—Same as repellent no. 7.

Fumigant No. 14.—Same as repellent no. 14.

Fumigant No. 16.—One pound of paradichlorobenzene dissolved in 2 quarts of cottonseed oil.

Fumigant No. 17.—One pint of *Black Leaf 50* (50 per cent free nicotine) mixed with 1 pint of summer spray oil (*Verdol*) to make a 25 per cent nicotine stock. This mixture was diluted and used at the rate of two parts of stock to three parts of water, giving a 10 per cent nicotine preparation.

The methods used in this study were similar to those used in the study of repellent paints. Untreated black walnut and apple cuttings of a size similar to those used in the repellent tests were infested with borers by the same method of

exposure. The exposure varied from 3 to 12 days, depending on the field population of adults. Eight groups of material were infested with borers; the first was put up July 8 and the last August 12. All

Table 4.—Results of fumigant paints applied to apple and walnut cuttings infested with *Chrysobothris femorata*, Stillwater, Okla., 1937.

Fumigant No.	Apple Cuttings				Walnut Cuttings			
	Number of Cuttings	Number of Borers		Per Cent Dead Borers	Number of Cuttings	Number of Borers		Per Cent Dead Borers
		Total	Dead			Total	Dead	
7	24	83	2	2.4	24	124	6	4.8
14	24	109	8	7.3	24	190	21	11.0
16	24	72	11	15.3	24	277	72	26.0
17	24	72	2	2.8	24	240	5	2.1
Checks	37	94	6	6.4	38	307	11	3.6

groups consisted of approximately 17 cuttings each of apple and walnut. On August 25, each group of infested cuttings was divided into five units of apple and five of walnut. Each unit consisted of three cuttings. One unit of apple and one of walnut from each group were treated with the same fumigant preparation. Four preparations were tested as shown under the formulas listed. These materials were applied with a brush as in the repellent tests. The fifth unit of both the apple and walnut cuttings (three to five of each) was kept untreated as a check. Examination was made one week later by barking the wood with a knife. Numbers of living and dead borers were recorded.

From the data presented in table 4, it appears that preparation no. 16, cottonseed oil and paradichlorobenzene, was the only one that gave any appreciable kill of borers, and even in this case the kill was not high enough to be of any great importance in controlling the borer.

Fumigants 7 and 17 on apple and 17 on walnut show a lower percentage of dead borers than their respective checks, but it is doubtful if this is significant.

TESTS WITH TREE WRAPS.—In the spring of 1937, the State Department of Highways set out elm trees along Highway No. 40 from Stillwater to a point 9 miles south. Permission was granted to use these trees in an experiment with wraps.

Five different kinds of paper were tried in the study.

Wrap No. 1.‡—A slightly creped paper, two thicknesses cemented together with asphaltum. This was put up in rolls 150 feet long and 4 inches wide.

Wrap No. 2.§—Single crinkle, two thicknesses cemented together with asphaltum. Same size rolls as no. 1. The crinkle across the band permits it to stretch as the tree grows.

Wrap No. 3.—Double crinkle, otherwise similar to no. 2. The double crinkle permits more stretch.

Wrap No. 4.—Single crinkle paper as in no. 2, but put up in rolls about 12 inches wide.

Wrap No. 5.—Medium grade wrapping paper. Rolls 4 inches wide were cut from an ordinary size bolt.

The wraps were applied to the trees in the spring before emergence of adults began. The wrap was started slightly below ground level, after the soil was dug away from the trunk, and wrapped spirally upward with a 50 per cent overlap giving two thicknesses of wrap. A twine string was tied around the top with a slip knot to hold the wrap in place and still allow the tree to grow and slip the string. Wrap no. 4, the wide roll, was cut into 36-inch strips and applied to the tree the long way of the strip. It was wrapped around the trunk and tied in several places with slip knots. The various wraps were distributed over the entire 9 miles of road with the exception of the wrapping paper, which was confined to the south 5 miles. The trunks of the trees were 1 to 2 inches in diameter and 5 to 7 feet in height. Observations were made several times during the summer as to conditions of wraps and trees. The last observations and records were taken October 21 to 26, at which time the wraps were removed and the trees closely examined.

‡ Manufactured by Weissinger Paper Company, Lansing, Michigan.

§ Wraps 2, 3 and 4 were manufactured by Arkel Safety Bag Company, 10 East Tenth Street, New York, N. Y.

After 11 trees had been wrapped with the wide strips (no. 4) it was decided to discontinue this wrap. It was difficult to handle and apply and did not present a neat appearance as did the other wraps. Observations showed that it did not stay in place so well as the narrow wraps and that it had to be repaired oftener.

It was found that the populations of adults and infestation of borers appeared quite uniform over the entire 9 miles of road so that the south half of the strip, where the wrapping paper was used, is considered comparable to the rest of the experimental layout.

In tabulating the data for table 5, it was assumed that the dead trees infested with borers were killed by these borers. It is recognized that this assumption is probably not entirely true, since a few of the trees might have been affected by disease or other factors which would have caused death unaided by the borers; or death might not have resulted had only the larvae and no other influence been present. Several of the dead trees were not infested with borers, as noted in table 5. They probably died from the effects of transplanting.

It is seen that nearly 48 per cent of the check trees were killed by borers while about 29 to 36 per cent of the various series of wrapped trees were killed. Protecting the trunk by wrapping reduced the number of trees killed by the flatheaded borer. The reduction in trees killed would have been somewhat higher except that half of each series of wraps was purposely not repaired as needed during the summer. Since the trees were watered frequently, the wraps tended to rot away from the bottom of the tree. During the latter part of the period when adult borers were active, nearly half of each series of wraps left the bottom of the tree exposed. Examination of the trees showed that these exposed bottoms were attacked by the borers in a number of cases.

While wrapping reduced the kill of trees by borers, it did not reduce the infestation of the remaining living trees as seen in column seven of table 5. Wraps 1, 2 and 5 had a higher percentage of living trees infested than the checks but it is believed this is because a greater percentage of the infested check trees and a smaller percentage of the wrapped trees were killed by borers.

Column nine of table 5 shows the percentages of trees killed or infested by borers. These data indicate that wrapping the trunk of the tree up as far as the first branches is not enough to prevent infestation of the tree. While a reduction of about 5.5 to 10 per cent is noted, this is not very great. It was observed that when the trunks were wrapped the beetles oviposited on the limbs above the wraps. To be really effective in preventing attack, protection should include the branches as well as the trunk, since the trunk was not attacked when wrapped.

There was little difference in results obtained from various wraps as regards protection of trees from borer infestation. However, ordinary wrapping paper was much less durable than the prepared wraps, necessitating frequent repairs. It was hard to apply without tearing. Wrap no. 1 handled well and presented a neat appearance. Its durability was equal to that of other prepared wraps.

The size of these trees when transplanted tended to make them susceptible to borer attack. They were fairly large so that they were probably weakened more than smaller trees would have been and were thus in a condition favoring attack. The smaller the tree the better its chances

Table 5.—Effect of different paper wraps on infestation of elm by *Chrysobothris femorata*, Stillwater, Okla., 1937.

Wrap No.	Number of Trees	Number of Trees Dead	Killed by Borers		Live Trees Infested		Total Infested*	
			Number	Per Cent	Number	Per Cent	Number	Per Cent
1	45	13	13	28.9	14	43.7	27	60.0
2	45	16	13	28.9	15	51.7	28	62.2
3	45	19	16	35.5	10	38.5	26	57.8
5	36	14	13	36.1	8	51.7	21	58.3
Check	168	86	80	47.6	34	41.5	114	67.8

* Includes those killed by borers.

for escaping injury because of its quicker recovery and growth following transplanting.

Houser (1937) in his experiments with wraps started from the top of the trunk and wrapped downward. He stated that this kind of spiral caught the rain, directed it inward to the trunk, and helped to maintain a more nearly normal moisture condition. It is felt that this is a good plan but no ill effects were noted in this experiment where the wrap was started at the bottom and wound upward.

SUMMARY.—Following is a summary of results of tests for control of the flatheaded apple tree borer in Oklahoma:

1.—Results from stomach poisons tested indicate that heavy applications of arsenical sprays are necessary to obtain good kills of the adult. Because of the activity of the beetles, it is believed spraying a small area will not protect trees.

2.—Repellent paints applied to growing apple trees reduced the number of parasitized borers by 33 per cent.

3.—A method of testing repellent mixtures by exposing cuttings in trees frequented by the adult borers was devised.

4.—Walnut cuttings were more heavily infested with borers than apple cuttings exposed at the same time.

5.—Creosote, paradichlorobenzene and carbolic acid were injurious to the bark of apple and walnut.

6.—Paraffin alone gave nearly as good repellence as paraffin and paradichlorobenzene, and did no injury to the wood.

7.—Most promising repellents are carbolineum preparations, paraffin and a naphthalene-flour-soap preparation.

8.—Materials tried as fumigants to kill the borer in the larval stage were ineffective.

9.—Protecting trees with a paper wrap materially reduced the number of trees killed by borers, but when wraps were applied to the trunk, the beetles shifted their attack to the limbs above the wrap.

10.—Paper wraps rotted away near the ground and needed attention at this point, especially when the trees were watered frequently.—8-17-38.

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Basic Copper Arsenate—A New Insecticide

*I. Chemical and Physical Studies**

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Basic copper arsenate was known to Klaproth as early as 1786 as the natural mineral olivenite. A century later Colori-ana prepared the mineral artificially. These and other early investigators examined the compound but the recent literature (last 30 years) is void of any reference to this substance.

Soon after the preparation of this compound by the authors, a German chemist, Klumpp, obtained patent rights both here and abroad for a method of manufacturing basic copper arsenate from copper oxide and arsenic acid.

CHEMICAL NATURE AND COMPOSITION.—Basic copper arsenate is a light gray-green material containing 56.2 per cent copper oxide (44.8 per cent metallic copper), 40.6 per cent arsenic pentoxide

* Sherwin-Williams research project.
† Early publication of this paper has been secured by payment of the printing charge.

and 3.2 per cent water of constitution. This analysis agrees with the formula $4CuO \cdot As_2O_5 \cdot H_2O$, but may also be written as $Cu_3(AsO_4)_2 \cdot Cu(OH)_2$ or as $Cu(CuOHAsO_4)$. The latter formula is more acceptable since it indicates the complex nature of the molecule.

Basic copper arsenate is a definite crystalline compound and may be isolated in a pure state. In this respect it differs from most other arsenical insecticides which are usually mixtures of various compounds. Basic copper arsenate is therefore capable of being reproduced with uniformity—a unique property among arsenical insecticides. This high degree of reproducibility in basic copper arsenate makes for uniform field behavior and dependability.

Basic copper arsenate may be classified as a very stable compound. It is extremely insoluble in water (about 3 milligrams of As_2O_5 per liter and about 0.05 milligram of Cu per liter).

The common arsenicals are subject to hydrolysis and the action of carbon dioxide, actions which result in an increase in water-soluble arsenic. Basic copper arsenate is not affected by water and only insignificantly by carbon dioxide. This arsenate is a product of hydrolysis, and treatment with boiling water for long periods of time produces no further change.

While 0.2 gram of carbon dioxide raised the water soluble arsenic pentoxide content of a 2-gram-per-liter suspension of basic calcium arsenate from 0.80 per cent to 10.4 per cent, the same treatment of basic copper arsenate caused a change only from 0.15 per cent to 0.35 per cent. The carbon dioxide of the air makes no detectable increase in the soluble arsenic pentoxide.

Although basic copper arsenate contains 3.2 per cent water of constitution, a temperature of about 700 degrees C. is required to dehydrate the compound. This phenomenon points to the fact that basic copper arsenate is a complex. The residue from such an ignition is found to be copper oxyarsenate, a bright green solid which will not rehydrate on standing in water. Copper oxyarsenate is of little value as an insecticide because of its high phytotoxicity.

PHYSICAL PROPERTIES.—As has been mentioned before, basic copper arsenate is a definite crystalline compound. In addition to its crystallinity, it can be produced with uniform particle size and shape. The particle size may be controlled by controlling the temperature, rate of formation, concentration of reactants, agitation, and acidity of mother liquor during precipitation. It is possible to produce crystals as large as 40 microns or smaller than one-half micron.

Since basic copper arsenate can be produced in various particle sizes with uniformity, it offers the entomologist an opportunity to study the effect of particle size on adhesion and coverage in the field. Such a study has been made, and the size for optimum field behavior has been found to be about 1 to 3 microns. Smaller and larger particles seem to be weathered off the foliage more readily. Smaller particles of basic copper arsenate demonstrate Brownian movement, which may account for their poorer adhesive qualities.

When basic copper arsenate is precipitated as crystals of 1- to 3-micron size, separated from its mother liquor in a filter press, washed and dried, the cake is found to be very friable and easily disintegrated by a mild process such as bolting. If, however, these crystals are ground in a mill, the uniformity of particle size is destroyed and the phytotoxicity is increased.

If basic copper arsenate is precipitated as very fine particles (one-half micron or less) the dried cake is hard, and grinding must be employed to reduce it to a usable powder. This ground material appears under the microscope as large aggregates and is really not so finely divided as the 1- to 3-micron crystals.

Large crystals of basic copper arsenate form very friable cakes but they are less effective as an insecticide because of slightly lower insect toxicity and poorer adhesion, coverage and deposit properties.

COMPATIBILITY.—Basic copper arsenate is stable in the presence of lime at ordinary temperatures, but when boiled with lime a slight decomposition occurs with the formation of calcium arsenate and the liberation of black copper oxide.

Basic copper arsenate is not affected by calcium caseinate or blood albumin. It is compatible with elemental sulfur and with Bordeaux mixture.

Basic copper arsenate differs from acid lead arsenate in that sodium chloride has no effect upon its solubility.

Liquid lime sulfur slowly decomposes basic copper arsenate over a period of several hours, but the process is greatly retarded as compared to the similar action on acid lead arsenate.

SUMMARY.—Basic copper arsenate is offered as a new insecticide-fungicide material. Its principal chemical and physical properties are as follows:

1.—Basic copper arsenate is very insoluble in water; the water-soluble As_2O_5 is about 3 milligrams per liter (0.15 per cent water-soluble As_2O_5) and the water-soluble copper about 0.05 milligram per liter.

2.—Basic copper arsenate is not subject to hydrolysis and only insignificantly affected by carbon dioxide.

3.—Basic copper arsenate is a definite crystalline chemical compound capable of being prepared in various particle sizes with uniformity.

4.—Crystals of about 1 to 3 microns in length have been found to give the optimum field behavior.

5.—Basic copper arsenate is compatible with lime (at ordinary temperatures), calcium caseinate, blood albumin, sulfur, Bordeaux mixture and NaCl solutions.—1-13-39.

Basic Copper Arsenate—A New Insecticide

*II. Insecticide and Phytotoxity Studies**

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The preceding paper (Witman, Waters and Almy) described the chemical and physical properties of basic copper arsenate, $Cu(CuOHAsO_4)$. This new insecticide was first made repeatedly in the laboratory by several methods until the conditions were determined for preparing a material with the most desirable physical and chemical properties from the standpoint of insecticidal and plant safety factors. Then several uniform 100-pound lots were made under controlled conditions in the chemical engineering laboratory. The materials used in the insecticide tests were lots of basic copper arsenate containing 44.8 per cent copper and 40.6 per cent As_2O_5, to which was added 2 per cent of zinc hydrate. This material had a particle size of 1 to 3 microns and a water-soluble As_2O_5 value of 0.15 per cent, when in equilibrium with CO_2 of the air.

In this arsenical material the factor of lead and lead residues is eliminated, and the copper factor, which gives the material decided promise as a fungicide, is introduced. It is much safer on most plant foliage than other effective arsenicals, as indicated by the relative values of water-soluble As_2O_5 determined after bubbling air up through a suspension of arsenical for 24 hours. When basic copper arsenate gives 0.15 per cent water-soluble As_2O_5 under these conditions, acid lead arsenate may give 0.8 per cent or higher, basic calcium arsenate from 2 to 3 per cent, and most commercial calcium arsenates 4 per cent or higher. Although water-soluble arsenic is low in basic copper arsenate, its toxicity to insects is of the same order as that of other commercial arsenicals.

The particle size of the material prepared under controlled conditions, which is comparable to the particle size of commercial lead arsenate, renders the suspension coverage, deposit and adhesion properties approximately the same as those of lead arsenate.

TOXICITY OF BASIC COPPER ARSENATE TO INSECTS.—Experiments have been conducted in the laboratory and field with a variety of truck crop, field crop, ornamental and fruit insects. Summary statements concerning the results of these tests are given here.

The Mexican bean beetle, *Epilachna varivestis* Muls., was used extensively as a test insect because it is rather difficult to kill, especially in the adult stage, and because bean foliage is very easily injured by arsenical and other spray materials. In extensive tests in laboratory and field basic copper arsenate at 1 pound of the material to 100 gallons of water gave 100 per cent control of larvae in 24 hours. The greater number were dead, and a few were moribund. It is necessary to use 3 pounds

* Sherwin-Williams research project.

† Early publication of this paper has been secured by payment of the printing charge.

to 100 gallons of spray to control the adults, as is also the case with calcium arsenate and lead arsenate.

Similar results were obtained when the Colorado potato beetle, *Leptinontarsa decemlineata* (Say), was used as a test insect. When the material was used at a strength of 1, 2 or 3 pounds to 100 gallons of water, all the larvae were killed in one or two days, depending on the concentration of the spray suspension and the larval instar. When the material was used at the rate of 3 pounds to 100 gallons as a control for the adults, 50 per cent mortality occurred in one day.‡

A dust containing 25 per cent basic copper arsenate gave excellent control of both Mexican bean beetle and Colorado potato beetle. Sulfur may be added to this dust for control of potato leafhopper without decreasing the efficiency of the basic copper arsenate.

Basic copper arsenate has been found to be more toxic than acid lead arsenate to larvae of the southern armyworm, *Prodenia eridania* (Cram.). The median lethal dosage (milligrams of insecticide per gram of insect body weight that causes 50 per cent kill of a group of larvae) of basic copper arsenate to last instar larvae has been found to be 0.18 to 0.20 milligram, while that of acid lead arsenate is 0.25 to 0.28 milligram. Based on mortality records taken at 48 hours, these data indicate that the toxicity of the two materials is approximately proportional to their respective arsenic pentoxide contents (lead arsenate 30.0 per cent As_2O_5 and basic copper arsenate 40.6 per cent As_2O_5).

In the laboratory some bean leaves were dusted with basic copper arsenate and others with lead arsenate. Both materials were applied at a rate of 0.06 milligram per square centimeter. Last instar southern armyworm larvae, with body weight of 400 to 500 milligrams, were caged individually with free access to these treated leaves (20 worms to a material). All larvae were dead within 48 hours. The same results were obtained at a dosage of 0.04 milligram of the material per square centimeter.

‡ The remaining adults were confined on the sprayed foliage for a 10-day period, during which time no further feeding or mortality occurred. When placed on unsprayed foliage at the end of this period they resumed feeding. In similar tests with lead arsenate and calcium arsenate, used at the rate of 3 pounds to 100 gallons, feeding by the insects ceased within 24 hours, and no insect mortality occurred during the first day or the following 10 days with either material. When placed on unsprayed foliage the beetles resumed feeding.

It was noted in these tests that the worms feeding on the leaves treated with lead arsenate stopped feeding first, consumed less leaf area, but did not die until the second day. Those feeding on leaves treated with basic copper arsenate fed for an hour or so longer, consumed more leaf area and were dead within 24 hours. The average quantity of lead arsenate consumed before death, when applied at the rate of 0.06 milligram per square centimeter, was 0.32 milligram, which is little if any higher than the minimum dosage required for 90 to 100 per cent mortality (0.30 to 0.31 milligram). The average quantity of basic copper arsenate consumed was 0.45 milligram or 1.8 times the dosage required for 90 to 100 per cent mortality (0.25 to 0.26 milligram). Apparently the initial effect of basic copper arsenate on the insect is slower than that of lead arsenate, a characteristic which results in a larger quantity of the former materials' being ingested before the insect is sickened to a point where it ceases feeding. For the control of gross feeding insects, especially adult beetles, this property is desirable, as it increases the chances of the insect's consuming a toxic dose before the poison takes effect. When the insecticide is present on foliage at an effective concentration, the additional quantity of foliage consumed is negligible, from the standpoint of foliage injury, because the total quantity of treated foliage consumed in either case is small.

Certain shade tree pests were used as experimental insects. Basic copper arsenate at the rate of 3 pounds to 100 gallons of water gave a complete control in 48 hours of both fall webworms, *Hyphantria cunia* (Drury), and catalpa sphinx worms, *Ceratonia catalpae* (Bdv.). These results were as good as the mortality in 48 hours produced by the use of acid lead arsenate at the same strength.

Extensive tests were made with basic copper arsenate to control potato leafhopper, *Empoasca fabae* (Harr.), on both bean and potato foliage. Neither dust nor spray of this material acted like Boredaux mixture, which controls leafhopper by causing plant juices to become toxic. Detailed experiments failed to indicate toxicity. However, basic copper arsenate dust has a very high repellent effect upon the leafhopper and affords a degree of protection for the plant for several days after

application, if the plant remains dry. Since basic copper arsenate is compatible with sulfur, spray or dust form, this combination will control the leafhopper on either bean or potato, as well as the red mite and the chewing insects found upon either crop.

During the latter part of the summer of 1938, Dr. C. O. Eddy and his co-workers made field tests with basic copper arsenate to control the velvetbean caterpillar, *Anticarsia gemmatilis* (Hbn.), on soy bean in Louisiana. They obtained excellent control with a single application as a straight dust. They found the median lethal dosage of basic copper arsenate and cryolite to the velvetbean caterpillar to be the same, 0.18 milligram. Basic copper arsenate, which has superior adhesive qualities, gave equal initial control and better residual control than cryolite in field tests against this insect.

PHYTOTOXICITY OF BASIC COPPER ARSENATE.—The insecticidal results that have been secured with this material are in general as good as, or better than, those with other arsenical materials. This in itself is not a striking improvement of an arsenical material. But when it is considered that the As_2O_5 solubility has been so greatly reduced without the loss of the insect toxicity, then it is evident that a decided improvement has been made. This material can be applied to most types of plants under ordinary ranges of temperatures and humidities found in the field without causing foliage injury. The group of stone fruits are an exception, and these are apparently affected by all copper materials. Bean foliage, which is very sensitive to arsenical injury, can be sprayed with basic copper arsenate and placed in a fog chamber (saturated humidity) for 72 hours without visible injury. If bean plants treated with commercial calcium arsenate are placed in the same condition the foliage suffers intensive injury in 2 hours and, if treated in like manner with acid lead arsenate, severe injury results in 12 hours.

Basic copper arsenate is the only arsenical that has been used upon soy bean in Louisiana to date without injuring this plant under conditions of high temperature and high humidity.

In addition to the severe and extreme laboratory tests used to determine plant injury, basic copper arsenate has been used upon a great variety of plant foliage in the field during the summer of 1938. Included in the list are economic crops such as bean, soy bean, cabbage, potatoes, tomatoes, grape and apple. No injury has occurred on any of these plants during periods of high temperature and high humidity.

The low phytotoxicity of basic copper arsenate can be correlated with its low water-soluble arsenic value and with its stability in the presence of weak acids, bases, salts, etc. It has the lowest soluble arsenic figure of any effective arsenical tested, and it has proved in general to be the safest of all the effective arsenicals when applied to plant foliage, except that of stone fruits.

PRELIMINARY FUNGICIDAL TESTS.—The copper content of basic copper arsenate, 44.8 per cent, is comparable with that of other insoluble copper compounds used as fungicides, such as basic copper sulphate, which contains 52 per cent copper.

In laboratory tests with cultures of bitter rot and brown rot fungi of apple on agar media, basic copper arsenate has proved more effective than either basic copper sulphate or 4-4-50 Bordeaux mixture. It therefore gives promise as a fungicide.

SUMMARY.—Following is a summary of results of tests with basic copper arsenate:

1.—In tests with Mexican bean beetle, Colorado potato beetle, southern armyworm, velvetbean caterpillar, fall webworm and catalpa sphinx worms, basic copper arsenate has proved fully as effective as acid lead arsenate or calcium arsenate.

2.—Basic copper arsenate has a slower initial effect, and a more rapid final effect on the insects tested than lead arsenate. This property increases the chance that gross feeding insects will ingest a toxic dose before the poison causes feeding to cease.

3.—Because of its low soluble As_2O_5 value and its stability, basic copper arsenate is much safer on most types of plant foliage than are other commercial arsenicals.

4.—In basic copper arsenate the factor of lead and lead residues is eliminated, and the copper factor is introduced, which gives the material decided promise as a fungicide.—1-13-39.

Laboratory Evaluation of Soil Poisons Used in Termite Control

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The use of soil poisons for the control of subterranean termites has been rapidly expanding in the past few years. It is known that the materials in most common use are of very limited effective duration in the soil. Up to the present time, however, the evaluation of possible new poisons has been rendered difficult and slow due to the fact that the customary field tests duplicating actual practice must run for a period of years before any indication of the merit of a chemical is obtained. A laboratory method that would in a short period of time give some basis for the elimination of the least promising of the new chemicals would greatly speed up developmental work. It is not anticipated that any laboratory method of evaluation will replace field tests, but it is hoped that the method herein described will prove to be a valuable supplement to the field tests.

Method.—The soil used in these tests was a typical brown silt loam surface soil (Illinois system of soil classification). Any soil in which termites can live ought to serve the purpose, although there would undoubtedly be a difference in the results just as there is now a great difference in the effectiveness of poisons in various soils in actual termite work. The soil was thoroughly air dried and crushed to a coarse granular state so that the largest particles would pass a 10-mesh sieve. The test apparatus consisted solely of jelly glasses, $3\frac{1}{2}$ inches tall, 2 inches inside diameter at the top and $1\frac{1}{2}$ inches inside diameter at the bottom. The checks were set up as follows: Two squares of ordinary toilet tissue paper were crumpled and placed in the glass and 15 cubic centimeters of tap water were poured thereon, after which the tissue was pressed down firmly against the bottom of the glass. Forty grams of soil were now poured into the glass. Fifteen cubic centimeters of water proved just sufficient to moisten the soil to the surface, thus leaving it in a rather loose, friable and easily penetrated condition. As soon as the soil was moist up to the surface, 15 to 25 termites of the worker caste were placed on the surface of the soil and the uncovered glass set aside for observation. No attempt was made to keep the glasses under controlled conditions of temperature and humidity.

In the case of the check glasses the termites invariably entered the soil in a few hours and often within 15 minutes. They stayed in the soil most of the time, although occasionally one would come to the surface for a few minutes. Insects in the check tests continued to be very active in the soil until the soil dried out and death occurred by desiccation. This usually occurred in about two weeks in dry summer weather. The termites were sometimes kept alive for several weeks by the addition of a few cubic centimeters of water every few days as needed.

In the tests the same technique was used as in the checks except that accurately measured amounts of poison were added to the soil before it was placed in the test glass or were dissolved in the water before the soil and water were brought together. The most convenient way to add the poison to the soil was to take 18 grams of the soil and grind it in a mortar with a pestle, after which 2 grams of the poison were thoroughly ground into it. Aliquot amounts of this finely ground poisoned soil were then mixed, without grinding, with sufficient of the granular unpoisoned soil to bring the total weight to 40 grams. When volatile poisons were used the grinding and mixing were done as rapidly as possible to avoid undue loss of poison by volatilization.

In all these tests orthodichlorbenzene was used as a standard of comparison for the fumigating type of poisons and sodium arsenite as a standard for the water soluble inorganic poisons. In each test of the fumigating type of poison a series of poison concentrations was used in an effort to determine for each material three factors: first, the minimum concentration that would kill all or nearly all the termites by contact within 24 hours after they were placed on the surface of the poisoned soil; second, the minimum con-

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centration that would repel the termites from entering the soil for 24 hours; and, third, the rate of loss of poison by evaporation from the soil as determined by the period of time before the termites would be able to enter the soil. It was soon ascertained that the minimum concentration of orthodichlorbenzene that would repel for 24 hours was in the neighborhood of 1–1000 so that test concentrations of the various poisons ranged up and down from this point.

In making the tests a series of from three to nine concentrations was generally used for each chemical under test and in all test glasses where the termites had not entered the soil by the second day the termites were removed and fresh ones added. At the time this change was made, the surface of the soil was very lightly scratched to prevent the formation of a hard crust that might mechanically repel the insects. Whenever the soil was deemed to be dry enough to be at all unattractive to the termites a few cubic centimeters of water were added to each test glass. The results were simply tabulated by charting the concentration of the chemical used against time of observation and placing an *o* where there was no penetration and *x* where penetration had occurred. When high concentrations were used so that an actual lethal effect was noted this was indicated by a *d*.

Where such soluble salts as the arsenicals and fluorides were used they were in some cases dissolved in the 15 cubic centimeters of water at definite concentrations and in other cases the dry salt was ground up with the soil. Only two factors could be noted in testing this type of material. First, the minimum repellant concentration and, second, the minimum concentration that killed the termites entering the soil within a given time.

Table 1.—Comparative evaluation of some soil poisons against termites.*

Material	Concentration in Soil	Observations After a Designated Period of Time, Expressed in Hours						
		15	39	63	87	136	160	180
Orthodichlorbenzene	1–200	*o*†	*d*†	*d*	*x*†	*x*	*x*	*x*
	1–400	*o*	*d*	*o*	*x*	*x*	*x*	*x*
	1–600	*o*	*o*	*x*	*x*	*x*	*x*	*x*
	1–800	*o*	*o*	*x*	*x*	*x*	*x*	*x*
	1–1000	*o*	*o*	*x*	*x*	*x*	*x*	*x*
Trichlorbenzene	1–200	*o*	*d*	*d*	*d*	*o*	*o*	*o*
	1–400	*o*	*d*	*d*	*d*	*o*	*o*	*o*
	1–600	*o*	*d*	*o*	*o*	*o*	*o*	*o*
	1–800	*o*	*d*	*o*	*o*	*o*	*o*	*o*
	1–1000	*o*	*d*	*o*	*o*	*o*	*o*	*o*
Crude dichlorpentane	1–200	*o*	*d*	*x*	*x*	*x*	*x*	*x*
	1–400	*o*	*d*	*x*	*x*	*x*	*x*	*x*
	1–600	*o*	*d*	*x*	*x*	*x*	*x*	*x*
	1–800	*o*	*x*	*x*	*x*	*x*	*x*	*x*
	1–1000	*o*	*o*	*x*	*x*	*x*	*x*	*x*
Crude diamyl phenol (50% in benzol)	1–200	*o*	*d*	*d*	*d*	*o*	*o*	*o*
	1–400	*o*	*o*	*o*	*o*	*o*	*o*	*o*
	1–600	*o*	*x*	*x*	*x*	*x*	*x*	*x*
	1–800	*o*	*o*	*x*	*x*	*x*	*x*	*x*
	1–1000	*x*	*x*	*x*	*x*	*x*	*x*	*x*

* Test started May 20, 1938.

† The termites were replaced in all the test glasses where they had not penetrated the soil at the end of the 39, 87 and 136 hour intervals. The symbol *o* indicates no penetration, *x* indicates penetration even though slight and *d* indicates a large percentage of the termites dead.

RESULTS.—The results obtained by application of the foregoing methods are given in tables 1, 2 and 3.

From the observations made in the course of this work it would seem to be a fairly accurate rule that so long as any appreciable odor of the chemical remains in the soil the termites will not enter it. This rule of thumb may be useful to the commercial termite control operator who in the course of his annual inspections

Table 2.—Comparative evaluation of some soil poisons at high dilutions against termites.*

MATERIAL	CONCENTRATION IN SOIL	OBSERVATIONS AFTER A DESIGNATED PERIOD OF TIME EXPRESSED IN HOURS			
		20	44	68	92
Orthodichlorbenzene	1–1000	*o*	*x*	*x*	*x*
	1–2000	*x*	*x*	*x*	*x*
	1–4000	*x*	*x*	*x*	*x*
Trichlorbenzene	1–1000	*d*	*d*	*d*	*d*
	1–2000	*o*	*o*	*o*	*x*
	1–4000	*o*	*o*	*x*	*x*
Monochlornaphthalene	1–1000	*d*	*d*	*d*	*d*
	1–2000	*o*	*o*	*o*	*x*
	1–4000	*x*	*x*	*x*	*x*
Dichlorpentane distillate	1–1000	*o*	*x*	*x*	*x*
	1–2000	*x*	*x*	*x*	*x*
	1–4000	*x*	*x*	*x*	*x*
Dichlorpentane residue	1–1000	*o*	*o*	*o*	*x*
	1–2000	*o*	*o*	*o*	*x*
	1–4000	*x*	*x*	*x*	*x*

* Test started June 10, 1938.

† Because of an insufficient supply of termites, no replacements were made during the course of these tests. The symbol *o* indicates no penetration, *x* indicates penetration even though slight and *d* indicates a large percentage of the termites dead.

wishes to determine the effective condition of the soil around a building.

Numerous water soluble compounds were tested, and sodium arsenate and arsenite were found to be much superior to sodium fluoride, copper sulfate or zinc chloride. Sodium pentachlorphenate was very effective when mixed dry with the soil, but when it was dissolved in water and soil poured upon the water there seemed to be a strong tendency for the soil to remove the pentachlorphenate as the solution came up through it. This was evidenced by the tendency of the termites to enter the soil only a short distance and survive, though they were definitely repelled from penetrating a greater depth.

SUMMARY.—A simple method of evaluating termite soil poisons is described and a few characteristic results are given. Trichlorbenzene and polychlorpentane are shown to be much superior to the orthodichlorbenzene now commonly recommended. Sodium arsenite and arsenate were the best of the inorganic compounds tried. Sodium pentachlorphenate is highly toxic and repellent, but seems to be easily removed from its water solution by the soil.—10-11-38.

Table 3.—Comparison with orthodichlorbenzene of two promising new soil fumigants against termites.*

MATERIAL	CONCENTRATION IN SOIL	OBSERVATIONS ON DESIGNATED DATES						
		8/25	8/26	8/27	8/28	8/29	8/30	8/31
Orthodichlorbenzene	1–500	*o*	*o*	*x*	*x*	*x*	*x*	*x*
	1–1000	*o*	*o*	*x*	*x*	*x*	*x*	*x*
	1–1500	*o*	*x*	*x*	*x*	*x*	*x*	*x*
	1–2000	*x*	*x*	*x*	*x*	*x*	*x*	*x*
	1–3000	*x*	*x*	*x*	*x*	*x*	*x*	*x*
	1–4000	*x*	*x*	*x*	*x*	*x*	*x*	*x*
Trichlorbenzene	1–500	*o*	*o*	*o*	*o*	*x*	*x*	*x*
	1–1000	*o*	*o*	*x*	*x*	*x*	*x*	*x*
	1–1500	*o*	*o*	*x*	*x*	*x*	*x*	*x*
	1–2000	*o*	*o*	*x*	*x*	*x*	*x*	*x*
	1–3000	*o*	*x*	*x*	*x*	*x*	*x*	*x*
	1–4000	*o*	*x*	*x*	*x*	*x*	*x*	*x*
Polychlorpentane	1–500	*o*	*o*	*o*	*o*	*o*	*o*	*x*
	1–1000	*o*	*o*	*o*	*o*	*o*	*o*	*x*
	1–1500	*o*	*o*	*o*	*o*	*x*	*x*	*x*
	1–2000	*o*	*o*	*x*	*x*	*x*	*x*	*x*
	1–3000	*o*	*o*	*x*	*x*	*x*	*x*	*x*
	1–4000	*o*	*x*	*x*	*x*	*x*	*x*	*x*

* Test started August 24, 1938, and observations made daily until August 31. In this test the termites were replaced every other day at the time the observation was made. The polychlorpentane was specially made by the Sharples Solvents Corporation and consists largely of tetrachlorpentane.

SCIENTIFIC NOTES

The Dung Rolling Beetle as a Host of a Sarcophagid Parasite

During 1936 two introductions of the dung-rolling beetle, *Canthon pilularius* (L.), were made into Porto Rico from Uvalde, Tex. The adult beetles were assembled by D. C. Parman, of the U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine, and sent by air express to Porto Rico on July 16 and 20.

At the time of arrival, a number of dipterous larvae and puparia were found in the shipping cages. Further examination showed that a number of dead beetles were present; in nearly all these beetles the head and thorax were broken away from the abdomen. Dissections of entire dead and living beetles disclosed the presence of a dipterous parasite within the abdomen of the adult beetles. The material was retained and the parasites allowed to develop. Determination of the parasites was made as *Sarcophaga alcedo* Ald.*

With the specimens available it was possible to make some observations on the habits and life cycle of this parasite. The adult flies deposit living larvae, and each female usually deposits them in pairs, although females have been observed to deposit a single larva and as many as four larvae at one deposition. A single female when stimulated to larviposition will deposit usually over 100 larvae during this period. From observations it was found that the number of larvae deposited ranged from 14 to 219. The parasite larvae are able to penetrate the integument of the beetle at any point, but the majority enter through the thinner chitinized portions of the abdomen. The females deposited directly on the beetles and also promiscuously in dung which was infested by beetles. In one case a female deposited in fresh dung. When deposition was made in non-infested dung, and adult beetles were later placed in the same dung, successful parasitization resulted. The length of the larval stage ranged from three to seven days. The adult beetles usually died two or three days previous to the emergence of the full grown parasite larva or larvae. As many as seven parasite larvae emerged from a single host.

The flies were given an opportunity to oviposit on dead beetles, but they showed no interest until dung was added, and they then proceeded to oviposit. The young larvae were seen crawling on the beetles, but none was successfully reared.

When the parasite larva has completed its development and is ready to emerge, it is found in the lower portion of the abdomen of the beetle. Apparently by the movement of its body the larva is able to break the abdomen from the thorax and to emerge from the anterior end of the abdomen. The larvae were not observed to feed after emergence. The larvae pupated within 24 hours after emergence and the pupal period ranged from 11 to 13 days. In one case pupation of two larvae took place within the abdomen of the beetle. Under laboratory conditions the adult flies were long-lived, the longest life recorded being 44 days. The adults mated readily in cloth cages immediately after emergence, and mating was frequently observed thereafter. The gestation period was found to be 12 days.

This fly is not specific in its host relationships. Two specimens of *Copris incertus* Say, another dung-rolling beetle, were successfully parasitized by this species.—11-12-38.

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* Determination by D. C. Hall, Bureau of Entomology and Plant Quarantine.

Breeding Areas of the Tomato Psyllid, *Paratrioza cockerelli* (Sulc)

Observations pertaining to spring breeding sources of the tomato psyllid, *Paratrioza cockerelli* (Sulc), have been made in conjunction with studies to determine the breeding areas of the beet leafhopper, *Eutettix tenellus* (Bak.), in southern Arizona, New Mexico and Texas.

Paratrioza cockerelli normally breeds abundantly on *Lycium andersonii* A. Gray and to some extent on *Lycium macrodon* A. Gray, which occur along washes in the semidesert areas of southern Arizona at altitudes below 3,000 feet. The distribution of *L. macrodon* is rather limited, but *L. andersonii* occurs commonly along washes throughout most of southern Arizona. Breeding normally occurs on these plants from January to May. The peak in numbers usually occurs late in April or early in May, after several generations have been produced. The adults move completely from the breeding source by the middle of June, and thereafter it is not possible to find the psyllid in its winter and spring breeding areas until an influx occurs late in October or early in November from an unknown source. Probably the more important factor causing a cessation in breeding by May is the fact that normally the host plants shed most of their leaves owing to lack of moisture. A hymenopterous parasite, *Tetrastichus* sp., attacks the nymphs in some locations, and numerous predators (coccinellids and chrysopids) reduce the numbers of eggs and nymphs to a varying degree from year to year. Data collected by means of insect traps (Fulton & Chamberlin 1931) located in the Grand Valley of western Colorado indicate a possibility that this district receives its psyllid infestation from southern Arizona, since movements of this insect have occurred coincidentally with movements of the beet leafhopper. Southern Arizona is known to be the principal source of beet leafhoppers which infect the Grand Valley district at least four-fifths of the years.

East of the Continental Divide, *Paratrioza cockerelli* and a closely related species, *P. mexicana* F. D. K., occur together in varying proportions, but the latter species apparently does not occur west of the Divide. This would indicate that the source of the psyllid west of the Divide is different from that east of the Divide. Limited observations indicate that the tomato psyllid and its closely related species *P. mexicana* breed on *Lycium* along the Rio Grande drainage above Laredo, Tex., for several hundred miles. There is a possibility that this is the main source of spring infestations that occur east of the Divide as far north as Colorado.—11-15-38.

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Peregrinator biannulipes Montr., a Predator of the Bamboo Powder-Post Beetle in Porto Rico

In the fall of 1936, during the course of an investigation of the bamboo powder-post beetle, *Dinoderus minutus* F., the writer found numerous nymphs of a small bug associated with this insect. These were found among the powdered wood and fibers resulting from heavy beetle infestation in bamboo stored in a shed on the station grounds at Mayagüez. The bodies of the nymphs were covered with wood dust and could scarcely be recognized without close examination. In a few instances these nymphs were seen attacking the adult beetles as they issued from galleries in the bamboo. A number of the nymphs reared to the adult stage on *D. minutus* adults were identified as *Peregrinator biannulipes* Montr. by H. G. Barber of the Bureau of Entomology and Plant Quarantine. So far as the writer can determine, this is the first record of the occurrence of this reduviid bug in Porto Rico and the first note of its feeding on a bostrichid.

When placed in a tube containing a number of powder-post beetles and some pieces of bamboo wood, a nymph or an adult of *Peregrinator biannulipes* almost immediately seized one of the beetles and began feeding by inserting its beak between the prothorax and mesothorax at a point to one side of the middle of the ventral portion, usually below the point where a wing cover was attached. The beetle struggled very little and soon died. After feeding for about 30 minutes, the predator searched for another beetle and repeated the process. This predator appears to require considerable time for development and to be rather long-lived. The specimens that were reared took seven months, November to June, to develop from small nymphs to adults. In cages stocked with powder-post beetles the reared adults remained alive for several months.

Further observations have indicated that while *Peregrinator biannulipes* was found in fairly large numbers during the fall and winter, to date it has exercised little if any control of the beetles; certainly no control that would be of any importance in preventing serious injury to susceptible bamboo wood.—11-21-38.

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A Disease of the Corn Ear Worm, *Heliothis obsoleta* (F.)

Considerable difficulty has arisen in recent years at the entomological laboratories of the University of California, Berkely, in the rearing of the corn ear worm, *Heliothis obsoleta* (F.), because of the high larval mortality due to a disease of unknown origin. In spite of the use of clean glassware, the mortality may be as high as 100 per cent; rarely is it lower than 10 per cent.

The first symptoms are the metallic luster of the larva, cessation of feeding, general paralysis and failure to molt. One to three days later, when the larva dies, the cuticle blackens and becomes soft and sticky, so that at the least tension it pullls apart, allowing the liquefied internal contents to flow out. In symptomatology this seems to be a wilt disease, but no polyhedral bodies have been seen.

The disease was first noticed in sixth instar larvae, and in succeeding generations it attacked progressively younger caterpillars, until it became very difficult to rear the corn ear worm past the third instar. No first instars, and few second, have been observed to die of the disease. The rate of mortality is higher when the larvae are on lettuce or alfalfa than when they are on tomato fruits or corn meal. The lowest mortality occurs when the larvae are feeding within entire tomatoes. The disease is evidently not due to nutritional disturbances, but no definite pathological evidence is at hand.

In order to facilitate experimental work, the writer will welcome information or suggestions for control from persons having similar experience with cutworms.—11-28-38.

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A Feeding Record of *Pterostichus (Poecilus) chalcites* (Say) Upon June Beetle Eggs and Grubs

In sample diggings of white grubs made during several years in various areas in southern Wisconsin, carabid larvae and adults have been common and, in some localities, very numerous. While it is evident that these larvae and adults could and probably did consume many eggs and grubs of the June beetles, the actual numbers destroyed have not been determined. Table 1 is a feeding record for a single carabid collected late in June, 1938. It was taken as a larva, which became adult by July 18, soon after the feeding tests were begun. The amounts consumed probably represent the minimum, since in most cases all the food supplied was eaten.

Table 1.—Number of June beetle eggs and larvae consumed by one carabid beetle.

PERIOD	STAGE	EGGS CONSUMED	LARVAE CONSUMED
Late in June to July 18	larva	17	—
July 18 to 21	adult	15	—
July 21 to 24	adult	19	1 (first instar)
July 24 to 27	adult	16	—
July 27 to Aug. 1	adult	14	1 (first instar)
Aug. 1 to 6	adult	20	—
Aug. 6 to 8	adult	12	—
Aug. 8 to 20	adult	13	—
Aug. 20 to 25	adult	0	—
Total		126	2

After August 25 no eggs or grubs were available to feed this beetle and it was killed and preserved for determination. The beetle was determined by L. L. Buchanan as *Pterostichus (Poecilus) chalcites* (Say). We have, therefore, no complete feeding record of a carabid through its larval and adult stages until natural death. However, the consumption of 109 eggs and two first-instar grubs in 38 days by the adult, and of 17 eggs between late June and July 18 by the larva, during which time it pupated and issued, is sufficient to show that carabids are of great importance in the natural control of June beetles, especially in some locations where the popu-

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lation of carabid adults and larvae of various species is higher than that of the June beetle material.—11-29-38.

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A Black Scale Parasite with Promising Qualities

In 1937, the University of California Citrus Experiment Station introduced into California 10 species of hymenopterous insects parasitic on the black scale, *Saissetia oleae* (Bern.), in addition to those already established. One of the new species, an encyrtid of the genus *Diversinervus*, proved to have certain habits which seemed to make it particularly suitable for effectively controlling black scale. Within a year the insectaries in southern California were producing and liberating the parasite in large numbers. The insectary of the Limoneira Company at Santa Paula alone produced over two million specimens in the summer of 1938. This is in line with the policy of liberating as widely as possible all species proved to be primary in habit, although several years must elapse before the true value of the parasites can be ascertained.

Smith (1930) in discussing the possibility of biological control of black scale stated that the lack of synchronization between host and parasite is the obstacle that must be met. As an example he cited the synchronization between *Lecanium corni* and its parasite *Encyrtus fuscus*. This parasite deposits its eggs in the newly hatched scale during spring and reaches maturity at the same time as its host the following year. The even annual broods of *L. corni* are inherent in the organism. The even annual broods of black scale, however, are not inherent but depend on external conditions. The existence of a black scale parasite similar in habit to *E. fuscus* seems doubtful, particularly since even broods of black scale are unknown in Africa, its original habitat.

It was surprising, therefore, to find that the development of *Diversinervus* was synchronized with that of the scale.

This parasite has the unique habit of ovipositing only in the large fused nerve ganglion of its host. The presence of the parasite does not affect the development of the host but the host does markedly affect the development of the parasite. In a rapidly developing host the eggs hatch in 10 days. The first larval instar is spent within the body ganglion. The development of the first instar is correlated with the development of the host. In a large host the first instar larvae may be fully three times the size of those of the same age in a small host. The larvae remain in the first instar within the ganglion until the host becomes mature and possesses fully developed ovarian eggs. Then the larvae break out of the ganglion and molt. Larval development then proceeds rapidly through three instars. If five or more larvae are present in a scale, it is prevented from depositing any eggs and its entire contents are consumed. The length of the pupal stage depends on the temperature. At a constant temperature the pupal period is almost equal to the incubation periods of the egg.

It is inhibition of the first ecdysis that brings about the synchronization of the life cycle of the parasite with that of its host.

Diversinervus is the only known parasite of black scale having a life cycle dependent on the host rather than on temperature alone. It has not been observed to complete its development in any host except *Saissetia oleae*, although it will oviposit in several species of coccids.

The black scale material received from the Transvaal was collected and shipped by the explorer, Harold Compere. From this material five females and several males were reared. No other specimens of this species were obtained. It was one of the least abundant of the parasites reproduced from the African shipments. Abundance, however, is not an indication of parasite efficiency. The efficiency of a parasite is determined by its ability to find its host at low densities.

Diversinervus was found to possess certain characteristics that tend to enhance this ability.

It is strongly built, ranges widely and is long lived.

It is bisexually gregarious so that a single host yields both sexes, insuring mating.

It has a slow rate of oviposition. A female may oviposit in a hundred hosts over a period of several months.

It will oviposit in all stages of scale except the small scale (less than 0.65 millimeters in length) and large scale in which the large body ganglion is beyond the reach of the parasite's ovipositor.

Although it is intrinsically inferior to such unsynchronized parasites as *Coccophagus rusti*, this inferiority is likely to be balanced by extrinsic superiority.

For maximum efficiency 5 to 25 individuals should develop in a single host. Under dense host conditions in the field, however, so few eggs may be deposited in a single host that host reproduction is not entirely inhibited, and the larvae develop in unfavorable conditions because of excess host fluids.

Apparently a light host population would favor the establishment of *Diversinervus*.—11-28-38.

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Prophanurus alecto Crawford in Porto Rico

In the summer of 1921, when attempting to obtain fresh material of *Trichogramma minutum* Riley for making a drawing, the writer reared an almost entirely black parasite from the eggs of *Diatraea saccharalis* (F.) which was identified by A. B. Gahan as *Prophanurus alecto* Crawford. Eggs of *Diatraea* collected a month later by F. Sein at Toa Baja, about 10 miles from Rio Piedras, also proved to be parasitized only by *Prophanurus*.

Since these records were made, *Prophanurus* has not again been collected in Porto Rico, despite the fact that an intensive investigation on parasitism of *Diatraea* eggs has been under way since September, 1936. On October 18, 1938, L. F. Martorell and the writer noted an egg cluster in a cane field at Isabela on which a small black wasp was resting, and the next day they made the same observation at Coloso. All the egg clusters collected from the northwestern corner of the Island were kept until emergence of parasites, and it was found that only

Prophanurus (the tentative identification was later confirmed by C. F. W. Muesebeck) was present at Isabela and Coloso (16 per cent and 14 per cent parasitism), some *Prophanurus* and some *Trichogramma* were present at Quebradillas (50 per cent parasitism), and only *Trichogramma* at Guajataca Dam (37 per cent parasitism).

A month later, in the same fields previously examined, no parasitized egg clusters were to be found, except at Guajataca Dam where parasitism by *Trichogramma* was 25 per cent. From the rare and sporadic appearance of *Prophanurus alecto* in the egg clusters of *Diatraea saccharalis* on sugar-cane in Porto Rico, and from the rapidity with which infestations die out, it might appear that this parasite normally exists on some other as yet undetermined host.—12-6-38.

GEORGE N. WOLCOTT, *University of Porto Rico Agricultural Experiment Station, Rio Piedras.*

Tartar Emetic in the Control of Citrus Thrips on Lemons

Tartar emetic (potassium antimony tartrate) has been included among the materials studied in connection with the control of the citrus thrips, *Scirtothrips citri* (Moult.) on lemons during the 1937 and 1938 seasons. Limited tests conducted during 1937 yielded promising results,* and more extensive work of the present season indicates that tartar emetic may prove valuable in the control of this relatively new and important pest of lemons. Nelson (1938) has reported satisfactory results with tartar emetic in the control of the gladiolus thrips, *Taeniothrips simplex* Morison.

In the earlier tests only sprays were considered, tartar emetic being used at 4 pounds per 100 gallons, alone, and with 8 pounds of cane sugar per 100 gallons. These early tests showed that tartar emetic was not effective in citrus thrips control unless sugar was incorporated in the mixture. It is not as yet known whether the "sweet" properties of the sugar as well as the hygroscopic action are both of importance. Since the citrus thrips generally avoid the blossoms of citrus, it appears probable that the hygroscopic action of sugar is its primary rôle in the mixture.

Brown sugar and molasses have been used and each is evidently as effective as cane sugar. The use of sugars may be undesirable under existing conditions since they furnish a favorable substratum for the growth of sooty molds. Glycerine has been substituted for sugar in tartar emetic sprays, and promising results have been obtained.

Dust mixtures of tartar emetic with sugars, glycerine and other materials are being studied. Promising results have been obtained in the field with certain of these mixtures.

A slight degree of foliage injury has resulted in all tests where tartar emetic has been applied in sprays. In several instances where there was a deposit of sulfur on the mature leaves at the time of application of tartar emetic sprays, the degree of injury was greater than where no sulfur was present, thus indicating that tartar emetic may be incompatible with sulfur. No injury has been observed where tartar emetic has been applied as dust.

* Unpublished mimeographed report of research work of the Department of Entomology, University of California Citrus Experiment Station, presented to the Citrus Entomology Committee, representing the citrus industry, on November 22, 1937.

Sprays with magnesium sulfate, phenothiazine and cryolite, alone and with sugar, were not effective, whereas nicotine sulfate incorporated with molasses gave promising results.

The results obtained in these studies with tartar emetic warrant further work with this and other antimony compounds, as well as other materials that may function as stomach toxicants in the control of the citrus thrips.—10-34-38.

A. M. BOYCE and C. O. PERSING, *University of California Citrus Experiment Station, Riverside.*

LITERATURE CITED

Nelson, R. H. 1938. Tartar emetic as a field spray against the gladiolus thrips. JOUR. ECON. ENT. 31(2):208–11. April.

Lead Arsenate as a Possible Control for the White Grub in Strawberries

The application of mixtures of lead arsenate and sand to the roots of strawberry plants for the control of the white grub, *Phyllophaga* spp., in experimental work in western New York during the season of 1938 resulted in a reduction of the loss of plants because of the feeding habits of this insect. Less than 2 per cent of the plants were lost in the lead arsenate plus sand treatments, whereas losses of from 15 per cent to 48 per cent resulted when plants were treated with magnesium arsenate plus sand mixtures, calomel plus gum arabic suspension, and ground glass. The average loss of plants in check plots was 45 per cent. Root treatments with calcium arsenate plus sand mixtures resulted in a total loss of plants because of the possible detrimental effect of the calcium arsenate on the strawberry roots.—12-19-38.

THEODORE W. KERR, JR., *Cornell University, Ithaca, N. Y.*

Magnesium Oxide as a "Corrective" for Cryolite Sprays

In the Middle West, tender varieties of apples such as the Jonathan may sometimes suffer from fruit injury where cryolite is used. In Georgia a "tip-end" or suture injury on peach has been reported from the use of cryolite or *Dutox*, but no foliage injury.

This past season we tried out magnesium oxide as a safener with promising results. In 1937, the United States Public Health Service reported that magnesium oxide was capable of removing small amounts of fluorides from water supplies. In our work we used magnesium oxide with fluorine compounds on smartweed foliage, which is very susceptible to fluorine injury. We were not able to test cryolite in this way since it is not injurious. *Dutox* or barium fluosilicate, however, will injure smartweed severely. When a dust of 50 per cent *Dutox* and 50 per cent magnesium oxide was applied practically no injury resulted.

Since Jonathans were not available, we were not able to test the effect on this variety. Because of the lack of a peach crop on account of frost injury we were unable to test magnesium oxide on peaches. There is every indication that those in a position to work with varieties susceptible to fluorine injury will find magnesium oxide a promising safener.

Since lime is not compatible with cryolite, it

follows that lime sulfur and Bordeaux are also not compatible. For sprays on apples a Bordeaux mixture was made by adding hydrated lime to copper sulfate until all the copper was precipitated as shown by testing the solution with potassium ferrocyanide. The formula used consisted of the following:

Copper sulfate	4 pounds
Hydrated lime	1¼ pounds
Magnesium oxide	6 pounds
Cryolite	4 pounds
Water	100 gallons

The amount of hydrated lime used varied slightly, depending upon the purity of the lime.

Chemically, only about 1¼ pounds of lime is necessary to precipitate all the copper in 4 pounds of copper sulfate. Any excess above 1¼ pounds merely helps to reduce copper injury in mixtures containing excess lime. The above combination with magnesium oxide was found to reduce copper injury and to be compatible with cryolite.

On peaches Bordeaux 4–4–50 will cause complete defoliation. A 4–4–50 plus 16 pounds of magnesium oxide in 100 gallons of water was effective in preventing defoliation.—12-22-38.

S. MARCOVITCH, *Tennessee Agricultural Experiment Station, Knoxville.*

Wool Grease or Degras as a Substitute for Mineral Oil in Sprays

It is now well known that in many sections of the country continuous spraying with summer mineral oil emulsions tends to produce foliage injury and to impair the vigor of the tree. During the past two seasons we have tested the effect of 1 per cent wool grease on apple, peach, beans, tomatoes and tobacco and observed no foliage injury whatsoever. In regions where much oil sprays are used it appears that wool grease may have some value.

Wool grease is rather difficult to emulsify. We succeeded in getting a good emulsion by first dissolving the warmed grease in an equal volume of kerosene. Blood albumin, two ounces per gallon of wool grease, was used as the emulsifying agent. The ingredients were then passed through the injector into the spray tank after the insecticides or fungicides had been added.

Three to 6 per cent wool grease emulsions did not appear toxic to codling moth eggs. When 3 per cent crude naphthalene was incorporated the ovidical efficiency was increased. Two per cent wool grease seemed to be effective against red spider. One per cent wool grease with copper fungicides appears to act as a safener for copper injury. It is possible that the grease covering over the leaf prevents the rapid absorption of soluble copper. The sticking properties of wool grease are excellent. In the trade, wool grease is also known as degras and listed for about 8 cents a pound.—12-22-38.

S. MARCOVITCH and W. W. STANLEY, *Tennessee Agricultural Experiment Station, Knoxville.*

An Agar Preparation for Feeding Adult Parasite Insects

While engaged in work upon oriental fruit moth parasites, the writer had occasion to develop a semi-solid food, with an agar base, for the feeding of the adult parasites. This had the advantage of being sufficiently solid to prevent the parasites from fouling themselves in it, thus avoiding a high mortality with certain species. It was used extensively in both the rearing cages and the shipping containers and gave excellent results under prevailing conditions. Instructions for the preparation of this food material have been presented in a multigraphed circular (ET-91) of the Bureau of Entomology and Plant Quarantine.

Experience by other workers, and in different regions, has indicated that the food prepared according to the formula given tends to liquefy at relative humidities of 50 per cent or more, and consequently tests have been made to determine the composition for use under varying conditions. The formulas given in table 1 are believed to be satisfactory within the ranges indicated.

Table 1.—Ager formulas used in feeding adult parasitic insects.

FORMULA	AGAR SOLUTION (1 per cent)	HONEY	GRANULATED SUGAR
No. 1 (up to 40% relative humidity)	50 cc.	25 cc.	—
No. 2 (40 to 70% relative humidity)	50 cc.	25 cc.	10 g.
No. 3 (50 to 90% relative humidity)	50 cc.	25 cc.	25 g.

When the preparation is made, a good grade of granular or dehydrated agar is used with a commercial grade of strained honey. The agar is added to water in the required amount to make a 1 per cent solution and is dissolved by heating in a double boiler. Following this the sugar is added, and finally the honey. Heating should be discontinued as soon as the honey is well mixed. As soon as the preparation begins to solidify it is ready for use and may be placed in small drops or in narrow strips upon cardboard or paraffined paper and placed in the cages or shipping containers.—1-20-39.

J. K. HOLLOWAY, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.*

The Asparagus Beetle in Utah

The asparagus beetle, *Crioceris asparagi* (L.), occurred in destructive numbers in Utah during 1938. An investigation of the matter, and inquiry among farmers in infested localities, disclosed the fact that one field of asparagus at Sunset, in Davis County, had been damaged by this pest in 1937. Evidently this beetle was breeding up to injurious numbers in 1936, and its introduction into Utah, in the opinion of the writer, must have occurred not later than 1935.

The attention of C. J. Sorenson, H. E. Dorst* and the writer was first called to the presence of this pest in Utah by Ray Whiting, district agricultural inspector of the Utah State Department of Agriculture. During the season Mr. Whiting cooperated on control tests and made a detailed study of the distribution of this insect.

* H. E. Dorst of the U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine, is located at the Utah Agricultural Experiment Station, cooperating with station entomologists on tomato insect investigations.

On May 3 the writer, accompanied by F. C. Harmston, examined asparagus fields near Ogden. At the time of observations the day was cold, but from 1 to 50 adult beetles were found on and in the sandy soil surrounding individual shoots in one field at Marriott; in addition, large numbers of eggs were present. Still heavier infestations were observed on older fence-row stocks which had not been cut recently.

Fortunately some of the more important asparagus growing areas of Utah had not become infested with this pest by the end of the past growing season. Field studies disclosed that in Davis County the infestation extended as far south as North Farmington, being general also at Clearfield, Clinton, Layton, Roy, Sunset and Syracuse. In Weber County injury was heaviest in fields at Marriott (northwest of Ogden), the infested area including Angus, Hooper, Kanesville, Ogden, Riverdale, and Slaterville, with a few beetles reaching the outskirts of Uintah and Plan City. Uncultivated asparagus growing along ditch banks, roadsides and in orchards evidently facilitated the spread of this pest in the area involved.

Heavy kills of larvae and adult beetles were observed following the application of strong dosages of lead arsenate to which miscible oil had been added, as well as from thorough dust applications of one part calcium arsenate diluted with three parts lime. Rotenone bearing sprays, at the rate of 3 pounds of 4 per cent rotenone bearing derris or cubé powder to 100 gallons of water, with a wetting agent added, gave good control. Satisfactory kills usually resulted when 1 per cent rotenone content cubé and derris dusts were properly applied.—1-20-39.

GEORGE F. KNOWLTON, *Utah Agricultural Experiment Station, Logan.*

Notes on *Empusa grylli* in Oklahoma

During July, 1938, a disease was reported by extension entomologists as killing a considerable number of grasshoppers in certain fields. In some fields, great numbers of these insects were killed to the extent that the odor from the decaying bodies was very noticeable. In the vicinity of Stillwater, the disease was confined to a few fields with a relatively small percentage of the grasshopper population infected. The general characteristics of the effect of the disease on the host were typical of that caused by *Empusa grylli* Fres. There was, however, one important exception; namely, the absence of the fine furry growth which, according to previous workers, appears on the outside of the body. Sick specimens taken in the afternoon between 5 and 7 o'clock from the top of grass and weeds died in 30 minutes to one hour. The fungus was demonstrated by examination of the body cavity and intestinal tract of sick specimens which were found filled with hyphal bodies that varied greatly in form.

All attempts to produce external conidia by placing the dead host in a moist bell jar were unsuccessful at temperatures of 50, 70, 80 and 90 degrees F., respectively. Dr. W. W. Ray of the Department of Botany and Plant Pathology, however, was able to cause the appearance of the external fungous growth by experiments to be reported upon later. The fungus was classified as *Empusa grylli* Fres.

Rainfall has a decided influence on the rate of grasshopper mortality caused by the disease. A considerable increase in the disease during a wet period in early July was noted and a method of checking this apparent correlation was sought. Since only a small percentage of the grasshopper population in this vicinity was infected, it was not practical to use sweepings to measure the daily variation of the disease.

A permanent plot method was decided upon. A plot 100 yards long and about 6 feet wide, along the border of an alfalfa field, was selected. The plot was covered with a stand of grass 2 to 3 feet high. Dead grasshoppers were collected from the plot each day during the period July 15 to September 1. Only those that died in the characteristic position, high on the plants, were counted. The daily mean temperature and the rainfall were taken from the records of the Oklahoma A. & M. College Weather Station located two and one-half miles from the plot.

The grasshopper population of the plot was estimated on July 15 to be about 10 to 12 grasshoppers per square yard. Although the population decreased steadily in the adjacent alfalfa, that of the plot of grass remained about the same, due to concentration of grasshoppers along the field margin as the season advanced. During the last week of August the population of the plot was estimated to be 8 to 10 grasshoppers per square yard. The number of grasshoppers dying during a single day never exceeded 52 or about 2½ per cent of the population.

The study showed that rainfall affects the rate of grasshopper mortality caused by the fungous disease. During the period July 15 to September 1 there were eight days that had rain. The amount varied from a trace on July 21 to 2.2 inches on August 16. Seven of these days were grouped into three wet periods. There were three main peaks in the mortality rate of the disease. These peaks occurred three to five days after the beginning of each of the wet periods. This increase of the disease, due to rainfall, is similar to the response of *Empusa grylli* as reported by Skaife.

Three methods were tried in an attempt to transmit the disease to healthy grasshoppers. Specimens were swept from fields that showed no signs of the disease. These grasshoppers were kept in cages for a six-day period to eliminate those that might be infected. It is believed that specimens free of the disease were obtained in this manner.

In the first method, a single healthy grasshopper was confined in a pill box with an infected one that was dying of the disease. A piece of moist cotton occupied about one-third of the box making it necessary for the two grasshoppers to be in contact. At the end of 12 hours the healthy specimen was removed and placed in a cage containing green food. At the end of the fifth day it was examined with a microscope for the presence of the fungus. Out of 20 specimens none died of the disease nor contained spores in their bodies. None of the controls was infected.

In the second method, the dying grasshoppers were replaced as a source of inoculum by specimens that had been dead one day. Two of the 20 healthy specimens died of the disease after being exposed. None of the controls was infected.

In the third case, bran was liberally moistened with a suspension of the hyphal bodies and spores in distilled water. This suspension was made by crushing the bodies of freshly dead specimens in water and straining to remove the larger particles. The wet bran was kept for a period of six days in a cage containing 20 healthy grasshoppers. At the end of this time five, or 25 per cent, of the specimens

had died of the disease. This is at least 10 times the highest rate of mortality observed in the plot. The other 15 grasshoppers appeared healthy but all contained spores in the intestinal tract. None of the controls was infected.

Since no external conidia were developed, it would seem that the disease may be transmitted by ingestion of the hyphal bodies and spores with the food. No data to support this suggestion have been reported by other workers. Attempts to grow the fungus on potato-dextrose, potato, pork and veal were unsuccessful.—1-28-39.

R. R. WALTON and F. A. FENTON, *Oklahoma Agricultural Experiment Station, Stillwater.*

Notes on Food for Corn Ear Worm Adults

In the course of our investigations it became desirable to rear a lot of larvae of the corn ear worm, *Heliothis obsoleta* (F.), during the winter months. Therefore a number of pupae were brought in from cold storage for emergence. The resulting adults were carefully fed a 10 per cent solution of honey in water, and special care was taken to keep the feeding dishes and food clean and sterile. No difficulty was experienced in keeping the adults alive and producing a large number of eggs for periods of two weeks or more. Three groups of 6 to 10 pairs of adults were reared in this way, but all eggs proved to be infertile. The fourth attempt was well under way when the honey and water that had been mixed for several days was found to have fermented and was fed to some of the adults. Three days later it was noticed that a number of eggs showed some incubation. A check of our notes showed that these were all from the cages where the adults had received the fermented food. This inspired a series of tests to compare the value of fermented and unfermented food for the adults, with the result that by feeding freshly fermented dilute honey we obtained an average of approximately 93 per cent hatchable eggs. Approximately 100 pairs of adults have been fed in our tests. In no case were fertile eggs found where unfermented food was given, whereas nearly all females receiving the freshly fermented food produced fertile eggs.

In some tests bakers' yeast was used to ferment the food and in others fermentation was caused by wild yeasts present in the air. There appears to be no difference in feeding value of these materials so far as the number and fertility of the eggs are concerned. The addition of the yeast, however, gives quicker fermentation with less danger of invasion by undesirable fungous growths.—2-1-39.

E. V. WALTER and D. W. LAHUE, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.*

Elm Leaf Beetle in Utah

During the summer of 1938 the elm leaf beetle, *Galerucella xanthomelaena* (Schr.), was found to be present in northern Utah at Smithfield, in Cache County. The foliage of six large elm trees was skeletonized, the owners questioning whether or not the trees would survive the attack. Ten nearby two-year-old elm trees were thoroughly treated with calcium arsenate dust, and greatly reduced subsequent injury resulted. Undoubtedly this species of insect had become established at Smithfield by 1937, to produce such an early, heavy infestation upon large trees; its introduction into Utah during 1936 or 1935 seems to be even more probable. Elms examined in various other Utah localities during 1938 showed no evidence that this insect was present.—1-30-39.

G. F. KNOWLTON and F. C. HARMSTON, *Utah Agricultural Experiment Station, Logan.*

JOURNAL OF ECONOMIC ENTOMOLOGY
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The Journal Makes Progress

THE February, 1938, issue of the JOURNAL OF ECONOMIC ENTOMOLOGY introduced to the Association members and JOURNAL subscribers a completely revised publication. Previous changes in the JOURNAL made in 1936 and 1937 had proceeded as far as possible within the limits of the old page size; but, in spite of these changes, the limit of flexibility and presentation of subject matter had been reached. This situation, together with a rapidly increasing amount of material for publication and changes in the printing industry itself, led to the even greater changes of 1938. The two most conspicuous features of the latest changes were the larger page size and the more easily read, more flexible two-column format.

Shortly after the approval of these major improvements by the Publications Committee at the 1937 annual meeting in Indianapolis, and later by the Association itself, a few members expressed concern about the advisability of this change. The eventual and general enthusiastic reception by Association membership of the JOURNAL in its new size and style confirmed a prediction made on the editorial page of the February, 1938, issue.

Aside from the physical or mechanical makeup of the JOURNAL itself, much progress has been made in other phases of the publication of results of scientific investigations. The establishment of a Publications Committee to review manuscripts has greatly improved the general quality of published articles. It has been a testimonial to the high caliber of entomologists as a group that they have accepted the critical reviews of their papers in a scientific spirit and cooperated with the Editor and Publications Committee to the fullest.

Each year the Publications Committee or the Association, sometimes both, adopt new rules to improve JOURNAL papers. At the 1938 annual meeting the most important changes were the adoption by the Association of recommendations contained in a Report of the Committee on Insecticide Terminology. It behooves all members of the Association to read carefully this report, printed in the Proceedings reported in this issue, and to be guided thereby. As already intimated, new procedures or rules have been established for improving in JOURNAL articles the readability, appearance, accuracy, organization, conciseness and logical deductions from established data. Obviously, the Editorial staff, the Publications Committee and even the Association itself cannot do the actual investigational work. Indirectly, however, by virtue of high publication ideals and sound standards of requirements for manuscript material, the JOURNAL can influence for the better the caliber of the entomological work which is done throughout the Americas.

It should be of interest to JOURNAL subscribers to know that Volume 31, 1938, if printed in the old format, would have required 1,156 pages. In other words, Volume 31 contained the equivalent of 92 more pages of the Volume 30 size than the actual number of pages in Volume 30. A corollary of this statement is that one page of the 1938 format is equivalent to 1.31 pages of the 1937 format. With the Publications Committee ruling at the Richmond meeting that it will continue to allow authors six pages gratis in the new format, authors will henceforth receive, as they received in 1938, one and two-thirds more pages of space gratis than in 1937 and previously. In spite of general increased printing costs, regardless of style, format or locality, such increases have been held in the case of the JOURNAL to a low level.

The membership of the Association is to be commended for the cooperation it has given to the JOURNAL staff and the Publications Committee. The results are evident. Continued progress is still the goal and constructive criticism is one of the means to this end.

REVIEWS

Our Shade Trees, by Ephraim Porter Felt, 1938. 187 pp., 31 pls., 1 fig. Orange Judd Publishing Co., 15 E. 26th St., New York, N. Y. $2.00.

This is a simply written textbook and guide for tree owners and field workers, tree wardens, city foresters, superintendents of estates and other persons engaged in the planting and care of shade trees.

Based on the author's long experience with shade tree problems, it offers a wealth of suggestions to persons interested in trees. Containing a résumé of shade tree culture, it supplies practical information for tree owners.

A brief history of noteworthy trees introduces the study of shade tree culture. The author points out the necessity for protecting trees from the handicaps imposed by present conditions and encourages the use of properly regulated, expert shade tree services.

Under the chapter entitled "General Shade Tree Care" are treated the following subjects: "Pruning and Cabling," "Cavities and Cavity Filling," "The Bark of the Tree," "Banding Trees," "The Roots and the Soil," "Growing Trees," "Feeding Trees," "Yearly Service" and "Things to Avoid." In Chapter 3, "The Language of Shade Trees," are described the reactions of trees to changing conditions.

In the chapter entitled "The Troubles of Shade Trees" are discussed introduced insects and plant diseases, such natural elements as wind storms, ice storms and lightning, and the artificial hazards caused by fire, roads, smoke, gas, public utilities, automobiles, real estate development and transplanting.

Useful data are made available in Chapter 5, "The Selection and Planting of Shade Trees," which lists the shade trees adapted to different sections of the country. Emphasized by the author are the value of past and future research and education to provide a basis for accurate diagnosis of shade tree troubles. The control of insects and diseases is explained fully and simply. A list of some of the more useful books on trees and shrubs is also contained in this publication.—9-21-38.

M. D. Farrar, *Illinois Natural History Survey, Urbana.*

A Field Study of the Flight, Oviposition and Establishment Periods in the Life Cycle of the European Corn Borer, *Pyrausta nubilalis* (Hbn.), and the Physical Factors Affecting Them, by George M. Stirrett. 1938. 101 pp. Scientific Agriculture **18.**

The European corn borer is dealt with in articles appearing in five successive issues of *Scientific Agriculture* under an equal number of subtitles. The first article deals with the history and importance of the European corn borer in southern Ontario, and the methods of study. The second presents the results of studies relative to the flight of the corn borer adults and the third with the moth flight and the influence of the physical factors upon flight. The fourth article of the series deals with the oviposition and establishment periods of the borer, egg mortality, larval mortality and survival. The final article discusses the seasonal characteristics of flight, oviposition and larval establishment, the seasonal effects of climate on the various stages of the borer and the factors causing fluctuations in borer populations in southern Ontario.

This publication is particularly timely because of the importance of the borer at the present time. The systematic studies, made over a period of 10 years, add greatly to the value of the results and allow for fairly definite conclusions regarding the effects of physical factors on corn borer abundance in southern Ontario. These studies might be applicable to other areas, and the purely ecological aspects of the work are of more than ordinary interest.

While the articles might have been reduced in size and number, the review of the literature on the subject treated is more than ordinarily complete. In several instances a summarization of the conclusions of the many authors on several phases of the work is given, which eliminates the necessity of referring to numerous papers on the subject.

The consideration given the effects of the numerous physical factors on insect behavior will be of interest to ecological workers in general and the very adequate summary of the reactions of the corn borer to these factors will be of special interest to those engaged in corn borer work.—10-12-38.

G. A. Ficht, *Purdue University Agricultural Experiment Station, Lafayette, Ind.*

CURRENT NOTES

Seventy-Fifth Anniversary, Entomological Society of Ontario

The seventy-fifth anniversary of the Entomological Society of Ontario was celebrated at the Ontario Agricultural College, Guelph, November 23–26, 1938.

The meetings were reported to be the most successful ever held by the society. Registered were 135 members, delegates and visitors. The attendance included members and delegates from across Canada and many representatives of societies and institutions in the United States. In connection with the meetings, letters of greeting and congratulation were received from many other societies, and educational institutions and governmental departments unable to be represented, and from several individuals interested in the society.

On Thursday evening, the Ontario Agricultural College sponsored a banquet for the society in the college cafeteria. The list of delegates and the letters of greeting and congratulation were read by Dr. Arthur Gibson, President of the society. Dr. G. I. Christie, President of the college, extended a welcome to the society on behalf of the college and offered his personal congratulations and those of the college on the occasion of the society's seventy-fifth anniversary.

Professor A. W. Baker gave an account of the founding and early history of the society, during which he introduced the three oldest living members, Dr. John Dearness, Dr. W. E. Saunders and Dr. Gibson. Dr. Saunders presented the society with the

bound manuscript of a bulletin, "Insects of Staple Crops," which was in course of preparation by his father, Dr. W. Saunders, one of the founders of the society.

At the sessions, papers were presented by the following entomologists: A. V. Mitchener, W. J. Brown, G. J. Spencer, A. D. Pickett, R. L. Post, C. G. MacNay, L. Caesar and G. Dustan, A. G. McNally, H. A. Gilbert, George M. Stirrett, A. D. Baker, W. A. Recks, R. E. Balch, Leonard S. MacLaine, C. E. Atwood, L. Daviault, A. W. A. Brown and H. S. Fleming, J. J. deGryse, W. G. Matthewman and A. Dustan, A. Kelsall, C. E. Palm, G. H. Hammond, Georges Maheux and Georges Gauthier, E. M. Walker, C. G. Lincoln, Rene Mougeot, H. C. Huckett, A. W. Baker, Georges Maheux and Pellerin Lagloire, R. W. Thompson, Geoffrey Beall, George M. Stirrett and I. L. Connors, J. B. Maltais, R. W. Leiby, C. H. Hadley, A. A. Hildebrand, C. L. Kennedy, L. Caesar, Arthur Gibson, H. A. U. Monro, E. N. Cory, R. B. Miller, W. M. Sprules, F. P. Ide, J. A. Hall, P. I. Bryce, W. G. Garlick, T. Armstrong, Joseph I. Beaulne, Andre A. Beaulieu, J. M. Barclay, Thelma Green, W. E. van Steenburgh and H. R. Boyce, L. R. Finlayson, H. G. James, George Wishart and H. L. Seaman.

One feature of the program was the moving pictures in color, "Insect Life," presented by Dr. A. L. Melander, City College of New York. These were shown at the Thursday afternoon session and at a special meeting in Memorial Hall on Friday, when they were witnessed by over 800 persons.

Officers of the society elected for 1938–1939 include the following: President, Dr. Georges Maheux, Department of Agriculture, Quebec, P. Q.; Vice-President, H. G. Crawford, Division of Entomology, Ottawa, Ont.; Secretary-Treasurer and Librarian, R. H. Ozburn, Guelph, Ont.

MEDAL FOR CANADIAN ENTOMOLOGIST

The medal awarded each year by the Professional Institute of the Civil Service of Canada was presented on November 28 to H. L. Seamans and those associated with him at the Dominion Entomological Laboratory, Lethbridge, Alberta, in recognition of work upon control of the pale western cutworm, *Porosagrotis orthogonia* (Morr.). The award recognizes outstanding contribution by professional or technical workers or groups of workers belonging to the Dominion or Provincial Civil Services in Canada, in science, economics, administration and associated fields of endeavor.

The committee of judges making the award consisted of Dr. H. M. Tory, President-Emeritus of the University of Alberta and President-Emeritus of the National Research Council of Canada, Sir Robert A. Falconer, President-Emeritus of the University of Toronto and Augustin Frigon, Assistant General Manager of the Canadian Broadcasting Corporation.

The medal was presented to Mr. Seamans at the annual luncheon of the Society and the formal presentation was followed by a public statement of congratulation and commendation by the Right Honourable William Lyon Mackenzie King, Prime Minister of Canada.

Mr. Seamans, who is officer in charge of the Dominion Entomological Laboratory of the Division of Entomology, Science Service of the Dominion Department of Agriculture at Lethbridge, was born in Wauwatosa, Wis., in 1891. He graduated with a B.S. degree from Montana State College in 1916 and was accorded the M.S. degree by the University of Saskatchewan, Saskatoon, in 1933. He was a member of the United States army 1917–1919, Assistant State Entomologist, Montana, 1916–1917, Special Field Agent, United States Department of Agriculture, 1917–1918 and Assistant Professor of Zoology, Montana State College, 1919–1921.

Mr. Seamans came to Canada in 1921 to take charge of the work of the Entomological Laboratory at Lethbridge. Among the major problems under investigation at this laboratory has been a study of the pale western cutworm. The investigations of this insect by Mr. Seamans began in Montana preceding his Canadian appointment and have been continued since. The practical results of the study include the successful forecasting of outbreaks of the insect a year in advance and the avoidance by cultural means of infestations in fields to be cropped. The work culminated in 1937 in the demonstration and widespread utilization of the so-called "starvation method" for the control of this pest in fields known to be infested.

NEWS FROM MEXICO

After serving for many years as Chief Entomologist and Head of the Department of Research in the Mexican Plant Protection Service, Dr. Alfons Dampf has resigned to accept a position as Professor of Entomology and Head of the Department of Entomology in the School of Biological Sciences in the Mexican Secretary of Education. Professor Dampf remains honorary consulting entomologist in the Department of Agriculture in problems relating to fruitfly and locust research and continues as head of the Entomological Laboratory of the Mexican Public Health Service. He is also Professor of Forest Entomology and Pathology in the Institut for Forest Research in Coyoacan, Mexican Federal District.

When the new Entomological Laboratory of the School of Biological Sciences in Mexico City was inaugurated September 3, 1938, and dedicated in the name of *Leland Ossian Howard* by the Honorable Josephus Daniels, Dr. Dampf presented a word sketch of Dr. Howard as man and scientist.

The new three story building of the Department of Entomology of the School of Biological Sciences, dedicated to research, is expected to be finished this month.

HONOR TO NEBRASKA ENTOMOLOGIST

A portrait of the late Lawrence Bruner was hung in Nebraska's Hall of Agricultural Achievement at a memorial ceremony held last December to honor the former professor of entomology at the state university.

Although a native of Pennsylvania, Professor Bruner spent most of his life in Nebraska, where he was known as the "commanding general" in the state's campaigns against insect foes. A. E. Sheldon, Superintendent of the Nebraska Historical Society and principal speaker at the memorial ceremony, termed Professor Bruner the "state's first great naturalist."

In 1880 and the year following, Professor Bruner was a field worker for the Smithsonian Institute.

In 1895 he went to South America at the request of the Argentine government to study grasshopper control problems. From 1895 until 1923, he was professor of entomology at the University of Nebraska He died in 1937.

PEST CONTROL OPERATORS

The third annual Pest Control Operators Conference at Purdue University was held, January 16–20, with 117 pest control operators from 20 states and Canada attending. This was the most successful conference thus far held, both in attendance and in instructional matter provided, according to reports.

The first Pest Control Operators Conference at Louisiana State University was held, January 30–February 1, under the direction of Dr. O. W. Rosewall, assisted by C. O. Eddy. Present were J. J. Davis, recently President of the American Association of Economic Entomologists, and William O. Buettner, Secretary of the National Pest Control Association.

The second Pest Control Operators Conference of the Pacific Coast was held at the University of California, February 20–22, under the leadership of Dr. William C. Herms. This conference was sponsored by the California Pest Control Association. The National Pest Control Association cooperated. Mr. Davis and Mr. Buettner were among the speakers who addressed the conference.

ENTOMOLOGIST MAYOR

C. S. Beckwith, cranberry specialist, New Jersey Agricultural Experiment Station, was recently elected Mayor of Pemberton, New Jersey.

MEETING OF THE PACIFIC SLOPE BRANCH

The Pacific Slope Branch of the American Association of Economic Entomologists will hold its twenty-fourth annual meeting at Stanford University, Calif., June 27–29, 1939. The officers are endeavoring to make this a notable meeting in the history of the Pacific Slope Branch, according to Ralph H. Smith, chairman. Accommodations at very moderate costs will be had in Lagunita Court, the new women's dormitory which is situated near the main university buildings in a beautiful setting of shrubbery and landscaping. There are also many good auto courts within a radius of a few miles of the campus. Stanford is noted for its picturesqueness and its hospitality, Chairman Smith writes.

The meeting will be concurrent with the twenty-third annual meeting of the Pacific Division of the American Association for the Advancement of Science and affiliated societies. Delegates will have the last of the week for visiting the Golden Gate International Exposition, the University of California and other places of special interest in the vicinity of San Francisco.

Entomologists of the central, eastern and the southern states are cordially invited by the chairman to attend the meeting.

J. J. DAVIS ACTIVE

When J. J. Davis retired from the Presidency of the American Association of Economic Entomologists in December, his entomological activities did not cease. Returning to Purdue University from Richmond, Virginia, he found himself in the midst of 9,000 visitors to the Purdue Agricultural Conference and with two programs to supervise, one on beekeeping and one on various insect problems.

The following week, he participated in the Third Annual Pest Control Operators Conference at Purdue at which 117 visitors registered from 20 states and Canada. Two weeks later he journeyed to Louisiana for another pest control conference, and by the middle of February he had left for California for the Second Pacific Slope Pest Control Operators Conference at Berkeley.

DEATH OF DR. BRITTON

Dr. Wilton Everett Britton, State Entomologist of Connecticut since 1901 and head of the Department of Entomology of the Agricultural Experiment Station in New Haven, died February 15, 1939. He was 70 years old.

He served as Associate Editor of the JOURNAL OF ECONOMIC ENTOMOLOGY, 1909 to 1928, and edited or assisted in the publication of a large number of papers on entomological subjects, among them "Check List of Insects of Connecticut" and a series entitled, "Guides to the Insects of Connecticut."

A graduate of Cornell University, Dr. Britton studied for and received his doctor's degree in 1903 from Yale University while working at the New Haven station.

His life will be reviewed in greater detail in a future issue of this publication.

MOKRZECKI MEMORIAL

Zygmunt Atanazy Mokrzecki, who was a foreign member of the American Association of Economic Entomologists at the time of his death, March 3, 1936, is the subject of a memorial publication (Extrait du Bulletin Entomologique de la Pologne T. XIV-XV, 1935–6) which is published in Polish with a summary in English.

This account of the life and work of Mokrzecki is of particular interest because he was one of the first of the foreign entomologists to adopt the American scheme of organization and attack on problems of economic entomology. Included in the volume are several pictures, one showing Dr. L. O. Howard on his visit to Skierniewicach.

DR. VAN DYKE TO RETIRE

According to a report, Dr. Edwin Cooper Van Dyke, since 1913 Professor of Entomology at the College of Agriculture of the University of California, will retire at the close of the academic year.

KINCAID WITH OCEANOGRAPHIC LABORATORIES

Dr. Trevor Kincaid, Chairman of the Department of Zoology of the University of Washington, is now a member of the staff of the Oceanographic Laboratories at Friday Harbor. During the regular summer session, June 19 to August 19, he will offer a course on marine plankton.

PROCEEDINGS OF THE FIFTY-FIRST ANNUAL MEETING

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Hotel John Marshall, Richmond, Virginia, December 26–30, 1938

The Hotel John Marshall at Richmond, Va., from December 26 to 30, was the scene of one of the best series of meetings ever held by this association. The attendance was excellent, the papers that were read were interesting and valuable, and the Joint Symposium with the Entomological Society of America and the Ecological Society was outstanding, drawing the largest attendance of any similar efforts.

The banquet of Virginia specialties was excellent, the entertainment was entertaining, and Dr. C. T. Brues' address on "Food, Drink and Evolution" kept an audience of 325 keenly interested.

The local committee of P. D. Sanders, G. T. French, H. W. Walker, W. J. Schoene, W. A. Bailey and W. D. Reed, Chairman, handled every detail in the most efficient and satisfactory manner, and Richmond surpassed the expected Virginia welcome with a sustained hospitality that will long be remembered.

COMMITTEE APPOINTMENTS

The following appointments were made during the year by President J. J. Davis:

COMMITTEE ON SECTION OF TEACHING:
John T. Creighton, *Chairman*, Paul Knight, H. O. Deay, C. L. Metcalf, W. B. Herms.

COMMITTEE ON NATIONAL INSECT CONTEST:
M. P. Jones, *Chairman*, G. D. Jones, F. E. Whitehead, E. O. Essig, C. C. Hamilton.

COMMITTEE ON ARRANGEMENTS:
W. D. Reed, *Chairman*, G. T. French, Exhibits, P. D. Sanders, Publicity, J. W. Bailey, Meeting Rooms and Equipment, H. G. Walker, Banquet, W. J. Schoene.

RESOLUTIONS COMMITTEE:
Harry S. Smith, *Chairman*, P. N. Annand, C. O. Eddy.

NOMINATING COMMITTEE:
Clay Lyle, *Chairman*, B. A. Porter, L. S. McLaine.

DELEGATE TO INTERNATIONAL CONGRESS OF ENTOMOLOGY IN BERLIN:
Arthur Gibson.

ASSOCIATION REPRESENTATIVE ON ARRANGEMENTS COMMITTEE FOR MIDSUMMER MEETING IN OTTAWA:
P. A. Readio.

REPRESENTATIVE OF ASSOCIATION AT ANNIVERSARY MEETING OF ONTARIO ENTOMOLOGICAL SOCIETY:
Ernest N. Cory.

REPORT OF THE SECRETARY AND BUSINESS MANAGER

On December 20, total membership paid through 1938 was 1,023. There were on that same date 73 members owing for 1937 and 1938, and 33 in arrears to 1936, making a total, all of whom apparently wish to remain active, of 1,129. In addition, cards to the number of 76 have been removed from the active files for the consideration of the Membership Committee. At this time last year only 790 members were paid for that current year, indicating a much healthier condition of the dues situation. Resignations total 14, deaths 8; mail has been returned as undeliverable from 21 members. Members having dues remitted and life members total 17, and there are 39 honorary members, bringing the total membership in good standing to date to 1,184. There are 94 applications waiting action by the Membership Committee.

The financial statement shows a balance of $8,102.32 in the checking account as against a balance last year of $10,497.36. The reduction is explainable on the basis of increased costs of publication. The JOURNAL OF ECONOMIC ENTOMOLOGY figures in 1937 were $5,521.25 as compared with $7,819.46 for the current year. Some charges carried over from the preceding year, in the 1938 cost, are included due to bookkeeping methods, and in addition the JOURNAL has been enlarged by the inclusion of a number of papers, the entire cost of which has been paid by the authors. In addition, the Index V was published at a cost of $3,396.25. Of this amount $402.50 was contributed in 1937 and $511.50 in 1938, on the basis of 50 cents per member. The balance is made up from sales, $187.60, and $2,284.65 from general funds. Sales of Indices I–IV amounted to $209.20 during the year. A page in the present JOURNAL is equivalent to 1.31 pages of the old format and the word costs are practically the same.

Disrupted conditions abroad have led to some cancellations and difficulties in collection, and no doubt have made receipt of the JOURNAL difficult for some subscribers.

Summary of Cash Receipts and Disbursements, American Association of Economic Entomologists

For the Fiscal Year Ended November 15, 1938

	TOTAL	JOURNAL	ASSOCIATION	INDICES I-IV	INDEX V
Balance, November 15, 1937	$10,497.36	$ 4,843.27	$3,978.33	$1,273.26	$ 402.50
Receipts:					
Subscriptions	5,959.05	5,959.05	.....	.....	.....
Advertising	231.46	231.46	.....	.....	.....
Reprints	1,386.45	1,386.45	.....	.....	.....
Back numbers and miscellaneous	189.90	189.90	.....	.....	.....
Dues	2,295.01	.....	2,295.01	.....	.....
Sales	396.80	.....	.....	209.20	187.60
Interest on bank deposit	46.77	.....	46.77	.....	.....
	$21,002.80	$12,610.13	$6,320.11	$1,482.46	$ 590.10
Disbursements:					
Audit of period ended Nov. 15, 1937	35.00	.....	35.00	.....	.....
Printing	9,743.97	5,905.61	672.11	.....	3,166.25
Engravings, drafting, etc.	603.92	603.92	.....	.....	.....
Editor's salary	475.00	475.00	.....	.....	.....
Salary of Assistant to Editor	300.00	300.00	.....	.....	.....
Salary of Secretary and Business Manager	400.00	200.00	200.00	.....	.....
Proof reading	225.00	.....	.....	.....	225.00
Postage, stationery, supplies	240.10	114.02	126.08	.....	.....
Telephone and telegraph	27.22	4.15	23.07	.....	.....
Traveling expenses:					
E. N. Cory to Indianapolis	100.68	.....	100.68	.....	.....
E. N. Cory to Richmond	9.35	.....	9.35	.....	.....
Convention expenses	40.02	.....	40.02	.....	.....
Branch expenses	27.52	.....	27.52	.....	.....
Clerical work	71.96	42.84	29.12	.....	.....
Surety bond for Secretary	12.50	.....	12.50	.....	.....
Stenographer	256.65	140.70	115.95	.....	.....
Rent of safety deposit box	3.30	.....	3.30	.....	.....
Refunds	22.10	10.00	7.10	.....	5.00
Bank collection charges	6.55	3.25	3.30	.....	.....
Membership list	78.97	14.79	16.89	47.29	.....
Express charges	187.77	5.18	.....	182.59	.....
Insurance	32.90	.....	32.90	.....	.....
	$12,900.48	$ 7,819.46	$1,454.89	$ 229.88	$3,396.25
Balance, November 15, 1938	$ 8,102.32	$ 4,790.67	$4,865.22	$1,252.58	$2,806.15*

Balance is represented by the following:

Prince Georges Bank and Trust Company, Hyattsville, Md. (Checking Account)	$ 4,570.92
First National Bank of Amherst, Mass. (Savings Account, Interest Rate 1½%)	3,153.14
Cash on hand (to be deposited)	115.50
Special deposit of December 24, 1938	262.76
	$ 8,102.32

* Debit balance.

Permanent Fund, American Association of Economic Entomologists

For the Period from November 15, 1937 to November 30, 1938

Balance, November 15, 1937, as per previous report		$18,828.40
Income for the period:		
Interest from securities	$ 267.50	
Interest from savings deposits	113.18	
Interest credited to book value of U. S. Savings Bonds	100.00	
Redemption of Federal Land Bank Bonds	450.00	
(Redeemed at Par, $4,000; Book Value was $3,550.00)		930.68
Balance, November 30, 1938		$19,759.08

The balance is invested as follows:

SECURITIES

Par Value		*Market Value*	*Book Value*	
$2000	Province of Ontario, 5%	$2,430.00	$2,000.00	
2500	U. S. Treasury Bonds, 3½%	2,730.25	2,484.00	
3000	U. S. Treasury Bonds 2½%	3,123.00	2,984.00	
5000	U. S. Savings Bonds, Series A	.....	4,000.00	
				$11,468.00

BANK DEPOSITS (SAVINGS ACCOUNTS)

Prince Georges Bank and Trust Company Hyattesville, Md. (Interest Rate 2% up to $5,000; 1% over $5,000)	$7,153.30	
Franklin County Trust Company, Greenfield, Mass. (Interest Rate, 2½%)	1,137.78	
		$ 8,291.08
		$19,759.08

College Park, Maryland
December 16, 1938

Dr. E. N. Cory, Secretary
American Association of Economic Entomologists
College Park, Maryland

Dear Dr. Cory:

I have supervised the examination of the accounts of the American Association of Economic Entomologists for the year ended November 15, 1938. In connection therewith, the record of cash receipts has been traced to bank statements for the period and found to be in substantial agreement. The verification of cash disbursements, which included examination of paid checks, invoices and other records proved that the recorded disbursements have been duly authorized and approved.

All bank balances of both the General Fund and the Permanent Fund have been verified by positive confirmations from the depository banks. All interest receipts have been confirmed in like manner. The securities have been verified by examination and all interest coupons accounted for. The Secretary's allocation of receipts and disbursements to Indices I through V has been accepted.

I hereby certify, in my opinion, the accompanying statements properly set forth the cash receipts and disbursements for the period, and the balance in custody of the Secretary.

(Signed) S. M. WEDEBERG
Certified Public Accountant

EASTERN BRANCH

The Eastern Branch of the American Association of Economic Entomologists met in Baltimore, Md., on November 17 and 18, 1938, at the Lord Baltimore Hotel, with V. I. Safro presiding. The program included 38 papers on various entomological subjects. The attendance was about 200.

The financial report showed receipts of $2,485.68 and expenditures of $707.64.

Clyde C. Hamilton was elected Chairman, and G. F. MacLeod Vice-Chairman for the coming year.

COTTON STATES BRANCH

The thirteenth annual meeting of the Cotton States Branch was held at New Orleans, La., on February 3, 4 and 5, 1938. The sessions on February 4 were held jointly with the Louisiana Entomologists, a branch of the Louisiana Academy of Science. The attendance was larger than that of any previous meeting of the branch, there being 150 names on the attendance record, and sessions were held on three days and three nights. Forty-seven papers were presented during the meeting. The program included symposia on "Forest Insects," led by Thomas E. Snyder, and "Citrus Insects and Citrus Spraying," led by Herbert Spencer. A number of growers and others interested in citrus growing in Louisiana attended the latter symposium. Conferences held during the meeting were those on thrips with C. O. Eddy, leader, the velvetbean caterpillar *Anticarsia gemmatilis* (Hbn.) as a pest of soybeans with C. M. Packard, leader, and the sweetpotato weevil with C. O. Eddy, leader. The March of Time film, "Pests of 1937" and U. S. Department of Agriculture films on the white-fringed beetle, periodical cicada and honeybee were shown. The program included visits to the entomological section of the Museum of Tropical Diseases of Tulane University and the sulfur wells south of New Orleans.

The President of the American Association of Economic Entomologists, J. J. Davis, attended the meeting as an official representative of the parent association, and addressed the branch at one of the sessions. A number of interesting exhibits, especially one on the white-fringed beetle, were installed in a spacious hall adjoining the meeting room. An informal "get-together" smoker was enjoyed on the night of February 2, and the annual banquet, with an elaborate floor show followed by a dance, was held on the night of February 4 in the La Louisiane, a famous restaurant in the French Quarter of New Orleans.

The Secretary-Treasurer reported receipts of $267.47, and expenditures of $104.58, leaving a balance of $162.89.

C. O. Eddy, University, La., and W. G. Bruce, Dallas, Tex., were elected Chairman and Vice-Chairman, respectively. Secretary-Treasurer Oliver I. Snapp was elected in 1937 for a three-year term.

It was decided to hold the 1939 meeting of the Branch in the state of Florida, the time and city to be selected later by the executive committee.

PACIFIC SLOPE BRANCH

The twenty-fourth annual meeting of the Pacific Slope Branch was held at Balboa Park, San Diego, Calif., June 23 and 24, 1938. During the sessions 22 papers were presented. These dealt with a wide range of entomological subjects, including insect toxicology and evaluation of field data.

The entomologists' dinner was held Thursday evening with Roy E. Campbell as toastmaster and J. J. Davis, President of the American Association of Economic Entomologists, and J. A. Hyslop as speakers.

Ralph H. Smith, University of California at Los Angeles, was elected Chairman of the branch; B. G. Thompson, Oregon State College, Corvallis, Vice-Chairman, and J. F. Lamiman, University of California, Davis, was continued as Secretary-Treasurer.

ERNEST N. CORY, *Secretary and Business Manager*

It was moved, seconded and carried that the report of the Secretary and Business Manager be accepted.

REPORT OF THE EXECUTIVE COMMITTEE

At the open meeting of the Executive Committee held Monday evening, December 26, 1938, the following reports were presented and, upon motion duly seconded, were accepted:

A. Joint Committee on Insect Collections.
B. Committee on Common Names.
C. Program Committee.
D. Committee on Codling Moth.
E. Committee on Insecticide Terminology.
F. Joint Committee on the Promotion of Official Entomology.
G. Committee on Popular Entomological Education.
H. Committee on the Relation of Entomology to Conservation.
I. Trustees for the Crop Protection Institute.
J. Representatives on the Council of Union of Biological Societies.
K. Representative on the Board of Trustees of the Tropical Plant Research Foundation.
L. Representatives on the National Research Council.
M. Committee on the Cooperation with Pest Control Operators.

Three of the above reports (B, E and I) were ordered to be read at the General Session.

The report of the Committee on National Insect Contest was accepted and the committee discharged without any further action on the matter.

The petition for the formation of a section on teaching was approved and referred to the Association for authorization.

The petition of the Florida Entomological Society for affiliation was approved and referred to the Association for confirmation.

The petition of the Newell Society for affiliation was approved and referred to the Association for confirmation.

The rule with regard to status and reinstatement of delinquent members was clarified with respect to what constitutes delinquency. Since the JOURNAL is continued for one year after delinquency in payments and the member is automatically dropped from the rolls after two years of non-payment of dues, it becomes necessary that the subscription price plus two years arrears in dues, together with the current year's fees, be paid in order to secure reinstatement.

C. D. Vreeland submitted an outline for the formation of an Association of Scientific Technicians 50 years of age or over. Details may be had from Mr. Vreeland, Little Falls, N. J.

The Program Committee was requested to take special cognizance of the fiftieth anniversary in planning next year's activities.

The holding of the principal business session on the next to the last day of the meeting was recommended.

It was recommended that $1,000 be transferred from Association funds to the Permanent Fund.

It was recommended that, in order to increase the interest from funds now held in the First National Bank of Amherst, $1,500 be invested in U. S. Savings Bonds.

Since S. A. Rohwer was appointed by the National Research Council for a term ending in June, 1940, and since he was the Chairman of a group of biological representatives, it was considered wise to accept the resignation of Dr. P. N. Annand and to reappoint Mr. Rohwer. At the same time Dr. Annand was requested to serve as Representative on the Council of the Union of Biological Societies.

It was recommended that the stipend of the Business Manager should be increased $200.00, to be taken in equal amounts from the two funds, and that $600.00 should be allowed for clerical assistance.

REPORT OF THE TRUSTEE FOR THE TROPICAL PLANT RESEARCH FOUNDATION

The Tropical Plant Research Foundation has not had any projects in operation during the past year and therefore no report to make regarding research activities. I have, however, a statement from Dr. William Crocker, the Acting Director and General Manager, which includes the information that the Foundation has $5,110.00 in Norway bonds, $400.48 in cash and various items as publications for sale and some office furniture as assets. As there seems little probability that projects will be undertaken in the near future, it is suggested that it may be best to terminate the Foundation and undertake to arrange with some research organization to administer its funds. However, no definite plan has been formulated, and it seems desirable to continue the relation of our society as heretofore.

—HERBERT OSBORN, *Trustee*

REPORT OF THE COUNCILOR TO THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Inasmuch as the Council holds at least one meeting daily during the sessions there is naturally a great deal of business transacted. In this report, however, mention will be made only of the more interesting items.

For a number of years the Jane M. Smith fund has provided for three life memberships, these being awarded on the basis of the longest continuous memberships in the American Association for the Advancement of Science. The sum, originally $5,000, with its accumulated surplus is now close to $10,000, and the Council voted to use this surplus as a rotating fund for financing more life memberships. Under this plan close to 50 life memberships will be created each year. It behooves everyone, therefore, to maintain his membership in good standing.

The American Institute of the City of New York was voted into membership on the basis of an academy. Thirty-two academies are now affiliated.

The Council authorized the formation of a list of younger scientific speakers who would be available to fill the demands for lecturers in various branches of science.

The by-laws were amended to provide that members in arrears be carried for only one year instead of two as has been the rule heretofore.

The Council elected as Fellows of the American Association for the Advancement of Science a list of some 140 members whose names were submitted by the secretaries of the various sections. The distribution of the new Fellows is interesting. One was nominated by the Section on Anthropology, 4 or 5 from two other sections, and 125 from the Section on Botany. The Section on Zoology submitted no nominees. The number of Fellows nominated ap-

pears in some cases to represent the initiative and activity of the chairman of the section.

The appointment of a committee to formulate a Council on Human Relations was authorized. This council is to be composed of 10 members representing 8 national organizations having to do with the social and human relation sciences. The social science organizations consequently will be prominently represented. The new council will parallel in organization the National Research Council and its services will be available to any organization, government or private, that may wish advice on problems in which the human relationship aspects call for special handling. The formation of such a body was suggested by the United States Forest Service. The Forest Service felt that such a council would be invaluable in giving advice on the human or social aspects of the many problems with which it has to deal. The advice of this council would be available, for example, on entomological matters, such as plant or insect quarantines, projects with which the public would be vitally concerned.

The Section on Chemistry made known its intentions to invite a foreign speaker each year for its annual meeting and asked the Council that this speaker be designated as the American Association for the Advancement of Science Lecturer in Chemistry, the expenses of this undertaking to be paid by the Section on Chemistry.

An expenditure of $2,000 was authorized for research grants. The individual yearly grants run from $65 to $225.

In order to be here to make this report your representative had to absent himself for part of the Friday morning session of the Council. Up to the time your representative left, Dr. W. B. Cannon had just been elected president for the ensuing year, and Dr. E. R. Long was elected to fill the vacancy on the Executive Committee created by the untimely death of Dr. Earl B. McKinley.

—JAMES I. HAMBLETON

COMMITTEE ON INSECT COLLECTIONS

(C. F. W. Muesebeck, Chairman, presented the report of the committee pertaining to the most important additions to institutional insect collections which, according to established custom, is published in the Annals of the Entomological Society of America.)

REPORT OF THE COMMITTEE ON COMMON NAMES OF INSECTS

During the past year your Committee has received proposals for 41 new common names, 11 changes in names already adopted, and one name in addition to those already adopted for *Heliothis obsoleta*. It is suggested that as heretofore this list be sent to all members of the Association in order that they may have opportunity to vote on these names, and that if 20 per cent or more of the votes cast for any given name are in opposition to that name it will be rejected, and that all the other names will be considered as accepted. The Committee further recommends that the names so approved be published in the JOURNAL as a supplement to the list published in volume 30, pages 527 to 560, 1937.

We find that many members are not giving adequate consideration to the proposed common names and are voting on names in which they have no interest. The Committee strongly recommends that the members vote on only those names on the propriety of which they have a very definite opinion. Inasmuch as 20 per cent is required to reject a name, general approval of the entire list makes it difficult for those intimately concerned with the name of a given insect to defeat a name which they consider improper.

—J. A. HYSLOP, *Chairman* L. M. PEAIRS
R. B. FRIEND CLAUDE WAKELAND
H. B. HUNGERFORD T. E. SNYDER

REPORT OF THE COMMITTEE ON THE CODLING MOTH

The activities of the Committee on the Codling Moth have been continued along the lines followed in previous years. Two general conferences were held during the winter of 1937–38. A brief session was held at Indianapolis, Ind., the afternoon of December 27, 1937, preceding the annual meeting of the Association. This was attended by about 72 workers from 22 states, the District of Columbia and Ontario.

A more extended general conference was held at Spokane, Wash., January 26–27, 1938, in conjunction with the annual meeting of the Western Cooperative Spray Project. About 85 were in attendance, from nine states, the District of Columbia and British Columbia. Although the attendance was chiefly from the western states, enough eastern workers were present to permit a helpful interchange of ideas between the two sections. Reports of both conferences have been mimeographed and made available to those interested.

Conferences have now been held every winter since 1934. The committee has decided that it is not necessary for the conference to become an annual fixture, and has voted not to sponsor a conference during the winter of 1938–39.

As in recent years, the committee has arranged with the Bureau of Entomology and Plant Quarantine to assemble, mimeograph and distribute a pool of information on the results obtained by various codling moth investigators during the 1938 season. This material will be sent out as unpublished data, and marked "Not for Publication." Reports have been invited from interested workers, and it is expected that the mimeographed reports will be distributed late in January.

—B. A. PORTER, *Chairman* R. L. WEBSTER
P. J. PARROTT H. N. WORTHLEY
W. A. ROSS C. R. CUTRIGHT

REPORT OF THE COMMITTEE ON THE PROMOTION OF OFFICIAL ENTOMOLOGY

During the year since the last report, inquiries have been made regarding any reported reductions in appropriations for essential phases of the entomological work of the federal government. There was reported to be some danger of reductions in certain regulatory undertakings, but it also appeared that this condition was being watched and cared for by persons directly concerned. The chairman of the committee wrote a letter in support of the original appropriation for these lines of work.

The reorganization of the Department of Agriculture does not at present appear to involve danger to the entomological activities of the Department,

or to indicate a disruption of the present organization. Further efforts at reorganization should, however, be carefully watched, to make sure that real damage is not done under the guise of administrative efficiency or for political expediency.

There seems to be danger to important research activities lurking in the tendency to emphasize crop control, which serves to place research activities in the background of importance. Until economic conditions are materially improved, there is not much that may be done about this tendency, but, when conditions improve, it will be incumbent on entomologists throughout the United States to insist upon a return to research as the method of greatest importance in the solution of the multitude of entomological problems with which the country is always faced. The recent broadening of research to include physiology and toxicology is greatly to be commended, and it cannot be too strongly insisted that there is danger to the welfare of the people of the country in any curtailment of entomological research. Problems of temporary expediency cannot with profit be permitted to overwhelm the work of greater and ultimate import.

Your present committee therefore recommends continuation of the committee and suggests that additions to its membership should be chiefly from persons geographically near enough to Washington and familiar enough with the work of the Bureau of Entomology and Plant Quarantine to assist as need be.

—E. F. PHILLIPS, *Chairman*
J. J. DAVIS
GEORGE A. DEAN

REPORT OF THE REPRESENTATIVE ON THE NATIONAL RESEARCH COUNCIL

In the report for 1937, it was pointed out that the representative of the American Association of Economic Entomologists had, in accordance with established practices of the National Research Council, been elected as a regular member of the Division of Biology and Agriculture and thus authorized to act as the representative of Society Group VIII. This action of the National Research Council was to remain effective until June 30, 1940. Under authorization and at the request of the Executive Committee of the Association, the undersigned has continued to serve as representative of the American Association of Economic Entomologists on the National Research Council. It is suggested that in the election of its representatives on the National Research Council, the Association recognize that the fiscal and report year of the National Research Council is from July 1 to June 30 and that at regular intervals and for stated periods the Association representative will be elected by the council to be the active representative for all the affiliated societies belonging to Group VIII.

Under its congressional and presidential authorization and under its charter, the National Research Council is a representative body. The Division of Biology and Agriculture of the council is concerned with activities of interest to the affiliated societies and stands ready to consider and, in so far as is within its power and province, to assist on questions which various societies may refer to it. It does not wish, and never has wished, to force itself on societies but leaves to them or their representative the presentation of matters to it.

Many of the projects and activities of the Division of Biology and Agriculture of the National Research Council require considerable study and are, therefore, of a continuing nature. Much of the work of the division has continued along the same lines as in previous years. Special consideration of two subjects of interest to entomologists was authorized at the last annual meeting in April, 1938. Reference to these and a few other matters coming under the activities of the council will be made in this report.

The council has discontinued the Division of Federal Relations which has for some years been one of the regular divisional units. In lieu of this division, arrangements are being made to have representatives of various federal agencies affiliated with various subject matter divisions. It would appear that this procedure will give better opportunity for the subject matter divisions of the council to become familiar with the work of the various federal agencies, and correspondingly the federal agencies will be better informed regarding work in their special fields with which the council is associated.

The standing committee on aerobiology has been active, securing cooperation from various sources and especially various commercial airlines. The membership of the committee has been extended to include an entomologist. The importance of the movement of insects in the upper air makes the work of this committee, and the procedures and information it may develop, of interest to entomologists, especially in connection with problems of insect control.

Upon recommendation of the Division of Biology and Agriculture, the National Research Council has subscribed for the support of a table in the Naples Zoological Station for 1938–39. This support makes the facilities of the station available to American scientists for the current year. Entomologists interested may obtain further information from the council.

H. P. Barss of the Office of Experiment Stations of the United States Department of Agriculture was elected to succeed himself as the representative of the Division of Biology and Agriculture on the Board of Governors of the Crop Protection Institute. In consideration of the report of the representative on the Board of Governors of the Crop Protection Institute at the annual meeting of the division, there was considerable discussion of matters pertaining to the Crop Protection Institute. This was crystallized in a motion authorizing the appointment of a special committee "to confer with the Crop Protection Institute with regard to broadening and modifying the scope of the work and inquiring into the general objectives of the work." Such a committee has been appointed and its report may, if the division so authorizes, be available to the Association by its next annual meeting.

At the annual meeting in April, 1938, the Division of Biology and Agriculture gave special attention to the affiliated project of Barro Colorado Island Laboratory maintained through support of the Institute for Research in Tropical America. This tropical research station, which has made possible investigations of considerable interest and value in the entomological field, is inadequately and precariously supported. The division heartily commends the activities of this laboratory and urges that institutions and organizations interested in biological research lend their support to its maintenance and to the amplification of its program. Representatives of the societies were requested to bring this to the atten-

tion of the various groups. The active part taken by Dr. Thomas Barbour individually and as Chairman of the Institute for Research in Tropical America is well known and recognized. The Division of Biology and Agriculture authorized the appointment of a special committee to consult with Dr. Barbour regarding the possibility of devising ways and means to insure the permanence of the laboratory.

—S. A. ROHWER

REPORT OF REPRESENTATIVES ON THE COUNCIL OF THE UNION OF AMERICAN BIOLOGICAL SOCIETIES

During the last five months of this year, a number of letters have been received from *Biological Abstracts* with reference to the new plan for organization of this publication for the year 1939, with particular reference to the desirability of issuing the abstracts in sections and to the possible desirability of providing a section specifically on entomology which would be supported to a considerable extent by the American Association of Economic Entomologists and other entomological societies.

Previous to the announcement of definite plans for publication in 1939, Dr. John E. Flynn of *Biological Abstracts* addressed Dr. E. N. Cory, indicating that it was believed that the time was ripe for the establishment of a separate section of *Biological Abstracts* to serve entomologists. Dr. Flynn expressed full appreciation that the abstracting of literature on entomology in *Biological Abstracts* has not been satisfactory in the past, that the coverage has been incomplete and that abstracts and indexes have been published late. He also suggested that, although the coverage of the literature remains unsatisfactory, this deficiency could be readily remedied, especially if a separate section for entomology were being published. A paragraph of Dr. Flynn's letter is quoted: "In recent correspondence with the bacteriologists, we have announced the willingness of the *Abstracts* to publish the bacteriology sections as a separate entity, and have invited the Society of American Bacteriologists to take control of the editorial and financial policies of such a section. In effect, we propose to decentralize *Biological Abstracts*. We have told them to write their own ticket and we would arrange to carry out whatever instructions their committee saw fit to make. The bacteriological portion of *Biological Abstracts* would be *their* journal. I believe the same offer would be made to the entomological societies if the societies were interested."

In view of the entomological abstracting facilities already available which are now supported by a number of entomologists, it was not felt that any definite encouragement could be given to Dr. Flynn that the entomologists would be interested in a proposition similar to that given the bacteriologists without some indication of the attitude of the membership to such a proposal. In order to obtain an indication of the attitude of the membership, a questionnaire was sent to the members of the American Association of Economic Entomologists with the announcement of the Richmond meeting, with the idea that the information thus elicited would give some basis for further discussion with Dr. Flynn and for a definite presentation of the subject to the Association at this meeting. Approximately 175 replies to the questionnaire were received; a summary of the result is recorded below:

(1) Do you believe that the entomologists need a new abstracting journal? Yes, 61 No, 111
(2) In your opinion did *Biological Abstracts* materially improve the abstracting facilities for entomological literature? Yes 64 No, 101
(3) In your opinion would the publication of a separate section on entomology by *Biological Abstracts* be of special value to entomologists? Yes, 95 No, 77
(4) Would you favor the society supporting such a section? Yes, 79 No, 86
(5) Do you believe that the *Biological Abstracts* has been most useful to entomologists through the abstracts of the literature on related sciences? Yes, 118 No, 40

It will be noted that, although the replies indicate by a small majority that a separate section on Entomology in *Biological Abstracts* would be of special value of entomologists, a minority indicate that they would favor the society supporting such a section.

The question in regard to supporting *Biological Abstracts* is, of course, of necessity extremely indefinite as we have no indication as to the amount of support from entomologists which would be necessary to insure publication of the abstract. We do have, however, the plan of the Society of American Bacteriologists which has been proposed, after discussion with *Biological Abstracts*, for consideration of the Council of the Society of American Bacteriologists. This proposes the following support and may be to a certain extent indicative of what would be required for a similar section for entomologists: The Society of American Bacteriologists will

(1) Appoint for *Abstracts of Microbiology* an editor, with power to select his associates, or an editorial board, not to exceed five in number.
(2) Conduct an active campaign designed to gain the support of the membership of the society.
(3) Agree to underwrite, during the calendar year 1939, *Abstracts of Bacteriology*, *Immunology* and *Parasitology* to the extent of guaranteeing from among the membership of the society 500 subscriptions at $5 each, or the equivalent thereof.
(4) Delegate to the appointed editor (or chairman of the editorial board) authority to determine all matters of policy and scope, and to act in behalf of the society in such matters as pertain directly to publication of the journal.
(5) Provide a moderate sum, not to exceed $500, for secretarial assistance to the editor and for incidental expenses.
(6) Require that *Biological Abstracts* agree to have the Society of American Bacteriologists represented on its Board of Trustees during the operation of this joint venture.

Due to possible differences in costs of publication of an entomological section and of the size of the edition as compared with a bacteriological section, it would be necessary, of course, to work out suitable arrangements taking these factors into consideration; the example of the suggested arrangement for bacteriological abstracts is offered merely as an indication of what might be feasible.

As indicated by the questionnaire, a large majority of entomologists are inclined to believe that *Biological Abstracts* has in the past been most useful to entomologists through the abstracts of literature on related sciences, probably because of the rather complete coverage already given strictly entomologi-

cal literature through other abstracting journals. Whether the needs of entomologists would be best served by their support of the *Abstracts* on the basis announced for 1939 or whether a section specifically designed to meet the needs of entomologists is desirable are questions which deserve careful consideration by the Association. The effect of a new section abstracting entomological literature in abstracting journals now in the field giving reasonably satisfactory service should also be included in the general consideration of the subject.

It should be made clear that the Board of Trustees of *Biological Abstracts* is not attempting to urge entomological support of a separate section. On the other hand, it is believed that it is sincerely attempting to determine the ways and means whereby the needs of entomologists and biologists in general can best be served by *Biological Abstracts*. It is the opinion of the board that any action should be taken only after thorough consideration of all of the various angles involved. To this end, it has requested that a joint committee representing the American Association of Economic Entomologists and the Entomological Society of America be appointed for consultation with the Board of Trustees of *Biological Abstracts*. It is the desire that this committee represent men in the field of entomology who are competent to give advice on the abstracting needs of entomology and that its function be to present to the Board of Trustees of *Biological Abstracts* the needs and attitudes of entomologists, both pro and con, toward abstracting facilities which are being currently given through *Biological Abstracts* and to make suggestions as to how these facilities might better meet the needs of entomologists. Your representative recommends that such a committee be appointed.

—P. N. ANNAND

REPORT OF THE COMMITTEE ON POPULAR ENTOMOLOGICAL EDUCATION

During the past year your committee had available a clip service of 430 typical newspapers of the United States. These were selected from as wide a range as possible, both geographically and editorially. Over 15,800 inches of material on entomology appeared in these papers in over 2,000 articles.

The subject that commanded the most attention of the year was grasshoppers, as could be quite naturally expected in a year of such serious grasshopper outbreaks. Next in order of popular interest was the Japanese beetle. The mosquito problem attracted major attention, probably due to the controversy between the entomologists and the wildlife conservationists. Other items that occupied considerable space were cotton insects, termites, truck crop insects, insecticides and quarantines, Dutch elm disease, blister rust and barberry eradication, parasites and apiculture. For the convenience of those interested in the relative amount of space occupied by these articles we are submitting table 1.

Table 1.—Relative amount of space devoted to newspaper articles on entomological subjects.

	ARTICLES	INCHES
Grasshoppers	1,091	8,088.0
Japanese beetle	220	1,679.0
General pests	180	1,456.0
Mosquito	157	1,105.5
Cotton insects	97	926.5
Termites and other forest insects	74	592.0
Truck crop	67	426.0
Insecticides	36	308.5
Quarantines	41	308.0
Dutch elm disease	37	279.0
Blister rust and barberry eradication	50	256.5
Parasites	14	154.5
Apiculture	20	109.5
Surveys	9	66.0
Silk culture	4	50.0
Totals	2,097	15,805.0

A survey was also carried on to ascertain the place that exhibits are taking in popular entomological education. The response to a questionnaire sent out by the committee was rather unsatisfactory, as but 12 states reported. These states reported 323 showings of exhibits on entomology with a grand total of attendance of 280,200 people. If we base our figures on the average obtained from the 12 states that reported and if they are truly samples of the entire United States, we find that entomologists put on during the past year over 1,000 showings of exhibits before an audience of 1,900,000 persons. A summary of the states reporting is shown in table 2.

Table 2.—Entomological exhibits and attendance, 1938

STATE	ATTENDANCE	SUBJECTS	SHOWINGS
Connecticut	—	1	1
Delaware	35,000	1	1
Iowa	205,000	3	25
Maryland	—	3	21
Missouri	10,000	2	51
Nebraska	—	1	85
New York	13,000	1	4
North Carolina	1,200	1	1
Ohio	10,000	2	2
Oklahoma	—	1	70
South Dakota	—	2	2
Texas	6,000	3	60
Totals	280,200	21	323
Average	40,029	2	27
Estimate—U. S.	1,921,392	?	1,296

Motion pictures and radio service were not surveyed by the committee this year.

—J. A. HYSLOP, *Chairman*
R. R. REPPERT
C. J. DRAKE

REPORT OF THE COMMITTEE ON INSECTICIDE TERMINOLOGY

Your Committee on Insecticide Terminology, in order to remedy at least part of the unfortunate errors that have crept into our JOURNAL and subjected us as an organization to possible criticisms from investigators in related fields of science, offers the following procedure for the guidance of authors of entomological papers and the Editor of the JOURNAL OF ECONOMIC ENTOMOLOGY:

1.—We recommend that authors, in preparing manuscripts for publication in the JOURNAL OF ECONOMIC ENTOMOLOGY, exert the strictest circumspection in naming any chemical compound whatsoever that may appear therein. The only system of chemical nomenclature and spelling that we consider acceptable is that used by *Chemical Abstracts*. In the event that the name of a compound is not found in a *Chemical Abstracts* index, the compound should be named by the *Chemical Abstracts* system as outlined in the following references:

a. Patterson and Curran, Jour. Am. Chem. Soc. **39**: 1623–38 (1917).

b. Patterson, ibid., **50**: 3074 (1928).
c. Crane, Jour. Chem. Ed., **8**: 1935 (1931).
d. The Report of the Nomenclature, Spelling and Pronunciation Committee of the American Chemical Society, Ind. Eng. Chem. News Ed., **12**: 202–5, (1934).
e. Decennial Index to *Chemical Abstracts*, 1927–1936, Subject Index; a summary of general principles, p. 3099; a list of practically all organic radicals and ring complexes, pp. 309–115.

2.—We recommend further that one of the two alternatives given below be followed in the preparation of manuscripts:

a. Include in the body of the text or in footnotes not only the chemical and/or trade names of the compounds used but also their known formulae, preferably the structural and at least the empirical formulae, or
b. If only the chemical names are given and formulae deleted from the body of the manuscript, then accompany such manuscript with a separate sheet on which preferably the structural and at least the empirical formulae of the compounds used are given. Such information is necessary in order that reviewers can determine whether chemical compounds have been properly classified and named. It would obviate unnecessary correspondence between the Editor, reviewers and authors, and, in addition, have considerable educational value.

3.—The use of such generic terms as "sulfonated oil," "sulfated higher alcohol," "sulfated fatty alcohol," "aliphatic thiocyanate," etc. should be avoided when specific compounds are referred to; the identity of the compound, either as to correct chemical name of the active ingredient or the trade label (source), should be given instead. The physical properties of compounds when known and used in specifications are especially important and should be given. Authors should recognize that their interpretation of the chemical nature of trade compounds may be erroneous and misleading.

Since naturally occurring products of more or less definite composition, such as bentonite, clays and talcs, are usually referred to under broad generic classification, it is highly desirable that the origin of these materials be specified. These products vary widely in their physical properties and the kind and amount of impurities they may contain, and such characteristics should be given. The same general principle would apply to commercial products such as limes, flours, petroleum oils, tar oils, animal and vegetable oils.

4.—The use of definite chemical names for mixtures of several related or different compounds should be avoided, and coined names or trade names which may be used instead should be explained in footnote reference. As an example, the misused specific name, "rotenone," is cited. Rotenone is a definite chemical compound. Hence, this specific name should not be used when ground derris, cubé or timbo roots or extractives of such roots is meant.

Your committee also has been asked to bring order out of the chaos that exists in the physicochemical phases of insecticide terminology.

We find that the present state of our knowledge of the action of supplements in sprays or dusts does not warrant any hard and fast definition of such terms as "spreader," "sticker," "wetting agent," or "activator." We therefore believe that when an author indicates the purpose for which he has used the supplement his data should definitely show whether or not the supplement has performed adequately for the purpose intended.

The term "supplement" is proposed for designating additions to spray or dust mixtures when the physicochemical action is not known and is not definitely determinable by the investigator and when no reference to specific action is made in the paper. This term is preferred to a wide range of names such as "auxiliary," "adjuvant," and similar terms which have been used in the literature.

The committee urges that entomologists use the utmost care in avoiding the misuse of the term "solution." This term should be applied to systems comprising two or more components but consisting of a single phase only. It should not be used in referring to suspensions of finely divided solids or emulsions.

The committee has observed marked improvement toward the correction of many of the faults in terminology during the past year. We compliment the Editor, the authors and reviewers on their efforts in bringing about these changes. We believe that future errors, improper, ambiguous, unintelligible or unfamiliar terminology can be avoided only by a definite procedure such as we have given in sections 1 to 4. Such procedure should lead to greater uniformity and clarity and enhance the future reference value of present work dealing with the chemical control of insects.

—HARRY F. DIETZ, *Chairman*
CHARLES M. SMITH
WILLIAM MOORE
F. L. CAMPBELL
R. H. ROBINSON

REPORT OF THE TRUSTEES OF THE CROP PROTECTION INSTITUTE

In 1938 the Crop Protection Institute brought to a close one of its investigations, continued others already under way in several states and initiated new investigations, all of which are noted in the paragraphs that follow.

ATLANTIC REFINING COMPANY.—This work was brought to a close early in the year. Sufficient information had been accumulated to indicate the field of utility of the product under study. The supporting company has begun marketing the material.

The studies were carried out primarily at the New Haven, Connecticut, experiment station, under the direction of W. E. Britton, Philip Garman and Neely Turner. Their object was to determine the performance and value of a sulfonated product known as *Ultrawet*, developed in the research laboratories of the supporting company. Combinations of *Ultrawet* with ground derris root, with nicotine sulfate and with other materials proved to fulfill certain useful purposes, including that of a safe and effective spray for the European corn borer, and an effective spray for onion thrips.

NATIONAL ANILINE AND CHEMICAL CO., INC.—The primary purpose of this project was to determine the fungicidal activity of a detergent which had been developed in the research laboratory of the supporting company, and to work out suitable combinations of this material with other substances. This aspect of the project was brought to a close at the end of 1937.

A further aspect, however, involved combination of the same detergent with powdered derris root. It

was found that these two materials reinforce each other. Various proportions of the two materials were studied in laboratory and greenhouse. These investigations were followed by closely checked field tests. It was found that a suitable mixture of the two substances provided an effective and inexpensive spray for various plant pests, including insects of the sucking type and insects with chewing mouthparts.

PYRETHRUM SPRAYS.—This investigation, supported by J. C. Makepeace and A. G. Kay, is brought to a close at the end of this calendar year. Materials have been developed which are now passing to the state of commercial utilization.

DOW CHEMICAL COMPANY.—This project is a continuation of previous studies. It involves investigations of the insecticidal activity of a large number of organic chemical compounds originated in the research laboratory of the supporting company. Formerly conducted at the Iowa experiment station, this work was transferred in 1937 to the Riverside, Calif., station and has been in progress at that point through 1938, under the immediate supervision of A. M. Boyce. Certain materials have reached the point of practical application, while others are still under experimental study. Beginning with the present month, this work is to be expanded by employment of a helper for J. F. Kagy, who has been the Institute investigator throughout the entire project. No change is contemplated, however, in the organization and purpose of the work, or in its location and direction.

RÖHM & HAAS COMPANY.—This project has continued through 1938 and has involved further detailed and fundamental studies of cuprous oxide, with and without the addition of other substances to increase safety and efficiency. In the course of the year Ross F. Suit, employed on this project, accepted another position, and J. W. Heuberger was engaged to take his place. The investigations are centered at the Geneva, N. Y., experiment station, under the direction of a committee consisting of J. G. Horsfall, W. H. Martin and S. E. A. McCallan.

An important aspect of the investigations for 1938 is a thorough examination of the influence of particle size on the performance of cuprous oxide. Three types of material have been under study, ranging in color from purple through red to yellow, the colors corresponding to decreasing particle size. It was found that the relative efficiency of these three types in laboratory tests was of the order 1, 2, 8; relative efficiency as seed protection treatments on peas, 1, 2, 4; and efficiency as a foliate spray on tomatoes, 1, 2, 3. These studies were followed by investigations of relative area and the relationship of area to fungicidal activity. A significant correlation was discovered.

STANDARD CHEMICAL PRODUCTS, INC.—This project involves two aspects: (a) herbicidal studies, largely in California, under the supervision of W. S. Robbins, of the Davis substation of the University of California, but with smaller scale work from time to time in the East; and (b) insecticidal studies, carried out jointly in the East and on the West Coast, particularly in California.

Herbicidal studies involve extensive investigations of the performance of a material called *Sinox*, which originated in France but is now being manufactured in the United States by the supporting company. The California plot tests and large-scale power applications have given control of various broad-leaved annual weeds of cereals, flax and onions. Excellent results have been obtained also in control of crab grass in lawns. Results of considerable promise have been secured against dandelions, mouse-eared chickweed and the plantains.

Plot tests in the East gave excellent results in control of the common yellow mustard, wild radish, orange hawkweed and devil's paintbrush.

In the insecticide studies the results of 1938 confirm those of 1937 in showing that 2 per cent of the dormant spray, *Elgetol*, will prevent hatching of overwintering egg-masses of the gypsy moth and the eastern tent caterpillar. The same material at 1 per cent has given excellent control of spruce gall aphids and pine leaf scale.

GENERAL CHEMICAL COMPANY.—The work in 1938 is a continuation of various developments of 1937 under the following headings:

1.—*Safened Calcium Arsenate.* An improved calcium arsenate with a higher factor of safety on sensitive plants, and with better adherence, has been under study in Louisiana, Mississippi, Long Island and Virginia. C. O. Eddy is supervisor in Louisiana, Clay Lyle in Mississippi, H. C. Huckett in Long Island and H. G. Walker in Virginia. Safety factors involve soybeans, sugar cane, field beans and sweet corn. Toxicity factors involve various insects, including the following: Soybean caterpillar, cotton boll weevil, cotton leaf caterpillar, sugarcane borer, potato flea beetle, Colorado potato beetle, Mexican bean beetle, European corn borer and cabbage worms. Adherence factors include cotton, soybeans and cabbage.

2.—*Basic Zinc Arsenate.* The principal aspect of this study is the development of sprays to control husk fly and codling moth on English walnuts in California. A. M. Boyce is the supervisor representing the Crop Protection Institute. Other studies include initial tests on peaches in Connecticut, and applications to cotton in Louisiana.

3.—*Copper Rotenone Dust.* This investigation involves field plots to determine the relative efficiency of a dust originated by the supporting company and including the active principles of ground derris together with copper in the form of a modified Bordeaux. The studies include applications on snap beans and on sweet corn in Long Island, under the supervision of H. C. Huckett.

4.—*Disease Control in Louisiana.* This investigation is under the supervision of C. W. Edgerton. The materials under study are a modified Bordeaux, as applied to potatoes, strawberries and cucumbers; a wettable sulfur, both alone and in combination with its modified Bordeaux, as applied to citrus; and an inoculated sulfur, as applied to sweet potato to control root rot.

U. S. RUBBER PRODUCTS, INC.—Early in 1938 a considerable number of materials from the laboratory of U. S. Rubber Products, Inc., were selected for preliminary study. Most of these substances had never been utilized in relation to plant or animal application. Various phases gave promising indications.

The work was then further organized on a six-months basis. The project was laid out as follows:

1.—*Stomach Poisons and Repellents.* This division was placed at Ohio State University, under the supervision of D. M. DeLong. Results to date at Ohio have shown that four or five materials have marked repellent qualities, and that an equal number are toxic as stomach poisons.

2.—*Contact Insecticides.* This aspect was placed at the New Hampshire experiment station.

3.—*Fumigants.* For the present this work is located at New Hampshire, where cultures happen to be available. It is hoped to transfer this to another state.

4.—*Improvement of Derris.* This investigation has given promising results. It is planned to place this aspect in one of the southern states.

5.—*Fungicides.* Since preliminary studies had been conducted at the Geneva, N. Y., station under the direction of J. G. Horsfall, the next stages were conducted at that station. Several materials of promise are under investigation.

6.—*Moth-Proofing Materials.* Several new compounds are giving marked promise.

The supporting company has assigned one of its highly trained chemists to full-time collaboration in this work.

EXPLORATORY WORK

Preliminary studies have been carried out with various materials in the course of 1938. Some of these give promise. The more important are listed under name of manufacturer as follows:

BENZOL PRODUCTS COMPANY.—The study involves the fungicidal activity of oxyquinolin compounds. The materials have given interesting indications.

CASEIN COMPANY OF AMERICA.—The company's research laboratory prepared combinations of casein with various toxicants, including sodium arsenate, copper sulfate, anhydrous copper sulfate and sulfur. Tests of these materials were run at Geneva, N. Y., Baton Rouge, La., and Durham, N. H. Results are promising.

W. J. CRAVEN AND CO., LTD., ENGLAND.—Experimental materials received from this company include various colloids. Their performance is interesting. Possible arrangements for work in the United States await further results in England.

HOOKER ELECTROCHEMICAL CO.—A new form of copper oxychloride, imported by this company, was given preliminary tests and showed good fungicidal activity. A proposed plan of operation was laid before the company.

SHELL PETROLEUM CORPORATION.—An insect repellent is owned by this company. In the hands of various members of the company's organization it has been tried out against various insects. Results are stated to be favorable. The company plans to authorize further exploration through the institute.

NUODEX PRODUCTS CO., INC.—This company manufactures various naphenates. In preliminary experiments, one or two of these gave somewhat interesting results and some gave no results. Additional samples, in which the compounds were made miscible with water, were tried out. One of them showed relatively high toxicity, greater in proportion than its relative cost. Naphthenic acid itself did not show toxicity to the test fungus. The company is now considering a small appropriation to provide for additional exploratory studies.

GENERAL INSTITUTE AFFAIRS

Paul Moore has continued to serve the Crop Protection Institute as its Secretary and Treasurer and has given it the untiring, faithful service which has characterized his work from the beginning.

C. P. I. Bulletin 64 was issued in 1938. This is entitled *New Wetting and Spreading Agent for Spray Materials.* G. L. Walker is the author.

Under the editorship of J. J. Davis the Crop Protection Institute Circular has been assembled and issued from time to time in 1938. It has met with wide interest.

The chairman prepared and transmitted to the board a series of eight communications dealing with various aspects of the administration of the Institute, including the following major topics: Selecting a Location for Institute Projects, Exploratory Work, the Institute's Overhead, the Project Committees, Contacts with Industry, Trends in Experiment Stations, Trends in Industry, Distribution of Institute Projects by States, Distribution of Projects by Subject Matter, the Research Output and Publications of the Institute.

By vote of the board these were edited, assembled and mimeographed, in order that copies might be available for interested persons.

—W. C. O'KANE, *Chairman*

REPORT OF THE COMMITTEE ON CO-OPERATION WITH NATIONAL PEST CONTROL OPERATORS

Last year your committee offered three recommendations, as follows: (1) that the sectional or regional branches be urged to provide a half day of discussion of household insect problems and invite pest control operators in the area to attend, (2) request that pest control operators suggest desirable and urgent research problems, (3) consider the possibilities and need of state legislation.

Only the Eastern Branch provided a half-day session devoted to household pests and invited commercial operators to attend. About 40 operators from New York, Washington and intermediate points attended. They have in various ways expressed appreciation of this cooperation.

No suggestions have come to us regarding desirable lines of research, although the National Pest Control Association has gone on record as recognizing the need of increased facilities for the study of household and structural pests and for rat control.

Legislation appears to be the problem of major importance at the present time, because of the invasion of numerous unscrupulous and unqualified termite and moth-proofing operators. Therefore, we offer the following suggestions for consideration as a basis for a model pest control operators' state law. Entomologists are urged to make a critical study of the several items and report their reactions to the committee.

PRESENT STATUS.—Three states (California, Louisiana and Mississippi) have state laws regulating pest control operators or pest exterminators, by which terms we refer to those engaged in the business of controlling insects and other arthropods, and rodents which infest structures. Many cities have ordinances in one way or another governing this business, most of which, however, refer to operations considered hazardous, particularly fumigation with hydrocyanic gas. The Mississippi law is too recent to judge its value; however, the California and Louisiana laws have been operating several years and its is generally agreed that they are of value.

STATE VERSUS CITY LAWS.—Many cities have enacted legislation because of the absence of state regulations. It is believed that state legislation is preferable for most pest control work and that city ordinances, usually sponsored by the health departments, should apply only to such regulations as are essential to the health and safety of the public.

SCOPE AND OBJECTIVES.—State laws should include commercial control of household pests and those affecting buildings. They should include licensing of firms, and provide sufficient authority to permit inspection of operations. They should include authority to license accredited operators and to revoke licenses for cause. They should not in any way interfere with individuals practicing pest control on his or her premises, excepting where the work involves apartments, hotels and the like and the use of dangerous chemicals. The ultimate object of any state law should be to protect the public and legitimate pest control operators.

ADMINISTRATION.—A state law should be administered by a qualified board of three to five members, one or at most two of whom should represent the pest control industry, one from the state agricultural experiment station, preferably the entomologist of such station, and one or more, depending on the size of the board, from such state agencies as have contact with the pest control industry. One of the members, who should not be a member of the industry, should be selected by the board as chairman or the active administrative official.

QUALIFICATIONS FOR PEST CONTROL WORK.—Requirements or prerequisites for licensing should include the following:

1. Three years of service in commercial pest control; or, in lieu of this apprenticeship service, graduation from an accredited institution where practical pest control is included as a part of the curriculum; or two years of service may be credited in lieu of a four-year course in an accredited institution providing an entomological curriculum.

2. Passing an examination which should be practical and inclusive.

Other suggestions are as follows:

1.—It would seem desirable to have several classifications. These classifications should include, perhaps, licensing for termite control, fumigation and other types of structural pest control.

2.—Licensed individuals or firms should not be permitted to advertise or use their licenses in any way which would appear unethical and/or indicative of state approval.

3.—It is our belief that state legislation will be of most value only if a budget is provided which will permit inspection of work, particularly termite jobs. We believe this is a feature of any state law just as much as inspection of restaurants, construction, etc.

4.—Licensing of a person or firm should be dependent on the standing of the firm or person and should definitely eliminate itinerant operators and those who provide an indefinite address as post office box number or general delivery and also those who simply have agency telephone numbers to receive calls.

5.—Other items which should be considered include reference to chemicals to be used, whether licensing should be confined to firms who would be responsible for their employees, penalties for violations, the license fee, the desirability of beginner's or probationary licenses and reporting requirements for certain types of work.

Your committee again suggests that Association branches consider including household problems in programs and inviting interested commercial operators, and urges all entomologists to study critically the legislation problems and report their reactions to the committee, so that a year hence definite suggestions may be made or perhaps a model law constructed.

—J. J. DAVIS, *Chairman*
E. A. BACK
G. L. HOCKENYOS

REPORT OF THE COMMITTEE ON THE RELATION OF ENTOMOLOGY TO CONSERVATION

The possible relations of entomology to conservation are so numerous and so diverse that this report cannot possible mention them all. Therefore, these comments will be limited to pointing out and illustrating by examples some of the more important generalizations that may be drawn.

But first let us consider the meaning of that much abused term, "conservation." Although some persons may interpret this term as meaning the saving of resources for the future, your committee's concept involves the idea of wise use of resources that takes into consideration both man's present and future requirements. The resources to be conserved include, of course, both those that are replaceable and those that are irreplaceable. We are concerned, however, only with the replaceable natural resources, both plants and animals, including human resources.

A moment's consideration indicates that conflicts both of opinion and interest are bound to arise when we attempt to manage living resources. The bison has disappeared from the plains, and sentimentalists sorrow over its passing; but if we desired the return of this animal to its former range, we could have it, provided we wished to surrender the economic advantages that man now enjoys because of its absence. Likewise we could restore the swamps and sloughs in many urban localities if it were not for the mosquito and the associated malarial problem. On the other hand, mosquito control of the wrong kind or control carried too far may result in destruction of wildlife habitats that constitute greater values than the destruction of the mosquito.

Thus one of the most difficult problems of conservation is to harmonize the multitude of conflicting values so that in the end the best long-time interests of man will be served. The entomologist can contribute to the solution of these difficult and important problems only in so far as he is able to sit in council with other biologists, economists and land managers, and with open mind help the group to arrive at a logical balancing of the various values in the best interest of mankind.

COOPERATIVE PLANNING.—Cooperative planning, in order to be successful, requires that representatives of all the interests involved be able and willing to recognize when collaboration is desirable, so that they can call upon others when necessary. In some instances the facts point only in one direction where it will appear that collaboration may be unnecessary. For instance, when human health is at stake, it would seem that the human interests must be protected even though the sacrifice of other values may be necessary. In such instances, there is no question of objective, but there may be questions of method and this should be considered with representatives of various interests.

In other instances, where human values are not at stake, collaboration is usually even more desirable. Not only should entomologists be willing to call on others for advice; they should also make their own special training available to others.

The committee has found several instances in

which entomologists were not consulted on questions concerning which their advice would have been invaluable, because the agency concerned did not know how or where entomological advice of the right kind could be obtained.

Therefore the committee suggests that this Association take steps through this committee to acquaint various conservation organizations with entomological facilities that may be placed at their disposal.

This committee has contacted a number of the leaders of conservation work and has been impressed with the cooperative attitude shown. This cooperative spirit is manifest in the increasing recognition entomology is being given by the agencies planning broad agricultural programs and putting those programs into effect. In formulation of the Ever-Normal Granary Program by the U. S. Department of Agriculture, problems of insect infestation in stored grain were given extensive consideration and were important factors in determining what trend the storage program should take in various parts of the country. The Agricultural Adjustment Administration and the Soil Conservation Service of the Department of Agriculture have exhibited definite interest in the effect of the present widespread grasshopper outbreak on their program and are taking an active interest in attempting to encourage the control of grasshoppers and to further the cooperative grasshopper control campaign by the federal government and the interested states. In certain counties in southern California, wireworms have been recognized by the Agricultural Adjustment Administration as being an important factor in the agricultural program and that Administration has asked that assistance be given them by entomologists in developing a program which will meet the needs of soil conservation and at the same time be consistent with wireworm control. Consideration is also being given by foresters and entomologists to the relation of the use of fire in insect control to forest development and other land uses.

EDUCATION.—Unfortunately, the education of entomologists does not always include those things that contribute most to conservation. Too little attention is paid in many entomological curriculums to the principals of economics and land or water management, and too much to the details of control for specific insects. As a result many of us have acquired a point of view that might be broadened to advantage. Therefore it seems advisable to urge schools to make the education basis on which entomological training rests as broad as practicable so that more entomologists will have a point of view that will make their services especially valuable in cooperative planning.

In addition to broader entomological education, additional facilities should be provided for special training that will fit entomologists to solve special problems in the various lines of conservation. For instance, it has been called to our attention that very few opportunities now exist for a student to obtain a knowledge of aquatic insects from both the taxonomic and ecological aspects. The need for men with such training is decidedly on the increase with the recent expansion of lake and stream management. Likewise, men trained to handle other ecological groups of insects, such as the soil insects, are almost non-existent. Teachers of entomology should bear these needs in mind, especially the need for developing men who are well trained in entomology but who also have a broad concept of the problems of land and water management.

INSECT CONTROL.—It has been said by some that entomologists are "too insecticide minded." This is probably true. Our first thought is to kill the pests by direct methods regardless of what else is killed incidentally. For instance, it is said that poison spray and baits do no damage because they are not dangerous to bird life, and it is probably true that birds are seldom killed directly by insecticides. We know, however, that insecticides cannot be applied so that their effects are limited to the insects against which they are directed. What is the effect of insecticides on an environment? We do not know of a single instance where the ecological effects of these substances have been adequately studied, although we understand that some work of this kind is now being carried on by the Bureau of Entomology and Plant Quarantine.

Clean culture has been sold to agriculturists and to a lesser degree to foresters, largely on the grounds that such procedures are desirable from the standpoint of insect or fungous control. Is there any instance where these assumptions have been experimentally demonstrated on a conclusive basis? But, the effects of so-called clean culture have been deleterious to wildlife, have contributed to soil erosion and may have affected seriously various biotic factors of insect control. It is time that entomologists took steps to determine the true entomological status of the fence row and the farm woodland.

Many of the specific points relative to entomology and conservation that should be considered were presented by the chairman in his presidential address of a year ago. The committee as a whole supports the ideas presented at that time. Although it is unnecessary to repeat the points made in that address, it seems desirable to reiterate some of the ideas; for instance, that in insect control every possible effort should be made to avoid injury to other valuable forms of life, that methods of control should be fitted to the specific case, that the values to be derived should be weighed against possible losses, that insect control projects should always be planned and supervised by competent entomologists and that every effort should be made to develop through research new methods of control that will be more suitable than those in current use. Specific reference was made to the possibility of developing mosquito control methods that would be effective without unduly damaging wildlife habitats.

RESEARCH.—It seems evident that entomology can contribute much to conservation by developing through research better methods of control of noxious species, especially through research in the field of insect ecology. For instance, ecological studies of the arthropods which attack wildlife or act as vectors of organisms that cause wild animal diseases should yield valuable results. Further ecological studies of forest and agricultural pests may lead to the development of better control measures through cultural means. The encouragement of ecological studies is therefore especially desirable from the standpoint of conservation.

SUMMARY.—The committee suggests:

1. That entomologists encourage collaboration in conservation projects so that a balancing of values in the best interest of mankind may be attained.

2. That this Association take steps through its Committee on the Relation of Entomology to Conservation to acquaint various conservation agencies

with the sources of reliable entomological information.

3. That educational institutions provide entomological training based on a broad foundation, including the principles of economics and management, so that entomologists will be equipped to collaborate most effectively with others.

4. That educational institutions be encouraged to offer training in special lines which will be helpful in the relatively new fields of conservation such as stream and lake management.

5. That insect control be considered in terms of the effect on all forms of life as well as the immediate effects on the insect which we wish to control.

6. That entomologists avoid recommendations on the grounds that certain procedures probably will be desirable, but for which they have no sound evidence of effectiveness, as in the case of many clean culture recommendations and the use of fire.

7. That the value and desirability of a specific control procedure be measured in terms of the values derived, over and above the cost including losses in other values that may result from the operations.

8. That efforts be made to use those control measures that are least likely to injury other forms of life, and through research to develop new methods of control that are more desirable from the standpoint of conservation than those now in current use.

9. Finally, that further ecological studies of insect vectors of disease-causing organisms of man and other animals, and similar studies of agricultural and forest insects, be encouraged.

—F. C. BISHOPP, *Chairman*
S. A. GRAHAM
A. L. STRAND

REPORT OF THE DELEGATE TO THE INTERNATIONAL CONGRESS OF ENTOMOLOGY AT BERLIN

The Seventh International Congress of Entomology under the presidency of Dr. E. Martini was held in Berlin, Germany, August 15–20, 1938. It was a pleasure to present to the Congress warm greetings from the American Association of Economic Entomologists. The Congress was officially opened by Herr Werner Ztschintzsch, the Under-Secretary of State in the Ministry of Education, in the absence of the Minister, Herr Rust. At the opening session on the morning of August 15, other important addresses were delivered by His Magnificence, Dr. Hoppe, Rector of the University of Berlin, Dr. Lippert, Chief Burgomaster and City President of Berlin, Dr. K. Jordon, Permanent Secretary of the International Congress of Entomology, and Dr. R. Jaennel of Paris.

For the general sessions and sectional meetings excellent accommodations were provided in the University of Berlin. Special sessions were held elsewhere. A large number of papers grouped under two sections, "general entomology" and "applied entomology," were presented. General entomology included contributions on systematic entomology, nomenclature, bibliography, morphology, physiology, embryology, genetics and ecology; applied entomology embraced papers on medical and veterinary entomology, apiculture and sericulture, forest entomology, viticulture, fruit culture, field and vegetable crops, stored product insects, teaching of entomology and biological control.

At the Congress representatives were present from 49 different countries. About 10 entomologists from the United States and Canada were in attendance. The total registration was 1,196. The official languages of the Congress were English, French, German, Italian, Portuguese and Spanish.

During the Congress a number of social entertainments were arranged for the pleasure of the delegates, as well as instructive excursions to various institutions of interest in Berlin and to other places such as the protected area of Schorfheide, Oderberg-Liepe district for entomological collecting and the historic city of Potsdam.

The Congress on the whole, in the opinion of your delegate, was most successful. Contributions of value to the science of entomology were presented, and attractive arrangements made for meeting and conversing with delegates from other countries. It was a real pleasure to meet again many of the prominent entomologists of Europe, and in addition to develop new friendships.

Following the Berlin meetings, many of the delegates visited Munich and certain other places of entomological interest, special arrangements for which had been made by the local committee.

—ARTHUR GIBSON

REPORT OF THE COMMITTEE ON A PROPOSED NATIONAL CONTEST FOR ENTOMOLOGY STUDENTS

At the annual meeting of the American Association of Economic Entomologists held in Indianapolis, Ind., December 27–31, 1937, Dr. F. E. Whitehead of Stillwater, Okla., presented a paper entitled, "A Proposed National Contest for Entomology Students." This paper was printed in the October, 1938, number of the JOURNAL OF ECONOMIC ENTOMOLOGY. The discussion following the presentation of the paper led to a motion for the President of the Association to appoint a committee to study the feasibility of such a contest. The motion was carried and the undersigned committee was appointed.

At the North Central States Entomologists Meeting in Columbus, Ohio, March 3, 1938, Dr. C. L. Metcalf, of Illinois, was asked to discuss Dr. Whitehead's paper. Dr. Metcalf, after conferring with other entomologists, suggested that contestants might compete at the sectional meetings and the top two or three participants from the sections compete at the national meeting. The expense to sectional meetings could be borne, possibly, by some fund within the college, but outside help would undoubtedly be necessary to finance the contestants to the national meeting. Contributions from commercial agencies might be accepted. The contestants should be prepared to discuss any one of about 100 insects and related anthropods, 20 of nationwide importance and the remainder divided according to the particular area represented by the Branches of the Association. The contest might well include both oral and written quizzes covering such points as scientific and common names, host plants or animals, nature and characteristics of injury, life cycle, distribution and control, and the formulation of letters replying to actual letters of inquiry from correspondents. It was also felt that the examination might well dwell upon the fundamentals of entomology, such as a knowledge of classifi-

cation, anatomy, physiology of insects; the ability to identify insects by means of keys; or a demonstration of the contestant's technique in pinning, mounting and labeling insects, or in dissecting to demonstrate internal organs. Dr. Metcalf moved that the North Central States Entomologists go on record as favoring the contest, and after a brief discussion the motion was carried.

Dr. C. C. Hamilton made a similar report on the contest at the Eastern Branch Meeting, November 17 and 18, 1938, but no comment was made and no action taken.

In order to bring this matter to the attention of entomologists in the various colleges, who would have much to do with such contests, and in order to get their views, a survey was made by this committee. Entomologists representing 56 colleges in the United States and Canada were canvassed. Seventeen were favorable to such a contest, 12 were opposed, 3 were non-committal and the remainder made no reply. Eighteen indicated they would participate in such a contest if it were undertaken.

In addition to the points referred to in Dr. Whitehead's paper, other comments were made relating to the contest, as follows: (1) Contests of this sort might further crowd the field of entomology; (2) students might better attend sessions and visit with entomologists; (3) student organizations in many universities have funds which could be used to finance the contestants at least to the sectional meetings; (4) contestants might be asked to bear a portion of the expense; (5) the institution or the entomology department might bear the expense; (6) the larger entomological departments might offer for awards research scholarships or graduate assistantships; (7) the winning contestant might be privileged to select the school he would prefer to attend; (8) a medal might be awarded to the individual winner; (9) an award might be in the form of a trophy for the institution represented by the winning contestant. Several other minor comments were made, which are available to anyone wishing to consider the matter further.

After due consideration to all that has been said your committee feels that a contest such as outlined by Dr. Whitehead is feasible, and should result in definite advantages to the entomological profession. It is therefore recommended that steps be taken to institute such a contest, or one similar to it, as soon as possible.

—M. P. JONES, *Chairman*
E. O. ESSIG
GEO. D. JONES
C. C. HAMILTON
F. E. WHITEHEAD

REPORT OF THE COMMITTEE ON TEACHING

The committee's study of teaching revealed the following:

The teaching phase of entomology is similar to all other phases in that it has many problems. The ultimate value of a section on teaching can be measured only by its ability to contribute to the permanence, stability and progress of the science.

Entomology, in keeping with other phases of the natural sciences, has contributed its just share to man's progress. However, it is generally agreed that we have thought more of the advancement of the science than we have of the application of the knowledge possessed to the strengthening of the social and economic fabrics of civilization. It is doubtless true that the teachers could aid in determining how we might apply the worthwhile things in our profession to the needs of man.

Entomological research has made great advancement, an advancement that is essential because research data are the foundation of all entomological work. This intensified research has resulted in the accumulation of stores of scientific data. This accumulation must continue without diminution. Nevertheless, there is a definite need for emphasis being placed on the coordination and dissemination of pertinent data. The evolutionary advance of research has exceeded the advance made by teaching. This is likely due, in great part, to the fact that methods and results of the former have been more freely discussed.

The American Association of Economic Entomologists was founded in 1889, especially for the advancement of the research phase of entomology. Fundamentally it was created in order to provide for the discussion, by its membership, of methods and results. When it was created its membership was predominantly research workers. However, today the membership embraces not only research workers but also teachers, extension entomologists, quarantine workers, apiculturists and commercial entomologists. The Constitution of the American Association of Economic Entomologists is very democratic in that it does not limit the membership to research workers; and it provides for the creation of sections where small interested groups may discuss their problems in detail. This inhibits overemphasis of any one particular phase of entomology.

There has been some advancement in teaching methods, though the advancement has apparently been due to individual endeavors and not to group efforts. The fact that this advancement has been of inestimable value to the profession should in no way obliterate the extreme value that would accrue from cooperative efforts.

The teacher of entomology is one of the most important units in the entomological system. The development of an unbiased research attitude in the beginning scientist is one of the most difficult tasks confronting men in this phase of the profession. They recognize that a truly worthwhile investigator must appreciate the value and necessity of all forms of scientific research; he must not look with disfavor upon the activities of others. Teachers realize that unless a broad aspect of the subject is presented they will contribute only to the stagnation of science; and that at times modern scientific training has sacrificed character building on the altar of scientific technicalities. The general attitude is that though there is a constant threat to eliminate idealism from scientific endeavors, such an elimination would result in a stagnating pooling of the elements of progression; therefore it behooves the teachers to maintain forever a strong element of idealism and constantly inculcate it into the students who come under their direction.

The entomology teachers control the supply tank of entomological talent. One of the greatest necessities of science is the injection of new blood, in the form of well trained students, into the arterial system of the profession. However, the injection of too great a quantity of one type of blood will upset the physiological balance of the profession, thereby causing a slow-down in activity with possibly com-

plete cessation of activity of certain parts. Some feel that entomological departments have at times overstressed the training of research entomologists, and neglected to train a sufficient number of men for other phases of work. Such a condition may be attributed to a lack of knowledge concerning field needs. Teachers should act as stabilizers in the trends and needs in the profession. Group discussions would materially facilitate the efforts of teachers to be of greater service to the profession by improving their teaching technique.

Since its creation in February, 1938, the Committee on Teaching has submitted questionnaires and petition blanks to the teaching members of the American Association of Economic Entomologists. Seventy-nine teachers, representing 30 institutions, have signed the petition urging the immediate creation of a special section of Teaching in the American Association of Economic Entomologists.

The committee hereby presents this petition to the executive committee and recommends that it transmit this request to the membership of the Association and urge the creation of this section during the 1938 meetings in the city of Richmond, Va. The committee also recommends that the newly created section then elect its officers, and that the first official meeting of this section be held in Columbus, Ohio, in 1939.

In conclusion, the Committee on Teaching submits the following objectives for the contemplated section:

The objectives of the Section of Teaching in the American Association of Economic Entomologists shall be:

1. To serve as an open forum where free exchange of ideas will be possible.
2. To provide for intimate contact which will be possible during the brief isolation period, thereby materially facilitating acquaintanceship.
3. To provide a place and time where young teachers may spend valuable time in close communion with older teachers; thereby improving the formers' teaching technique.
4. To provide for unified action in behalf of a continued improvement of teaching, and to broaden the view of all teachers.
5. To provide a place for studying improvement in teaching methods, including modern apparatus, visual aids, laboratory manuals, etc.
6. To study the content of introductory courses; and the desired curriculums for students planning to pursue advanced degree work.
7. To integrate entomological instruction with the liberal trends in education.
8. To make research and other entomologists better acquainted with the many problems confronting the teachers; while permitting these other professional entomologists to offer just and fair criticism of the end-products of the classroom.
9. To study the trends and needs in the field of entomology, thereby preventing the impregnation of the field with too many individuals cut to the same pattern.
10. To arrange for a free interchange of materials between institutions.
11. To devise and study more effective methods whereby departments in educational institutions might more accurately assimilate and disseminate entomological knowledge.
12. To outline programs that would eventually lead to a broadening of the opportunities for human service, which in the final analysis are the measuring stick of scientific values.

—JOHN T. CREIGHTON, *Chairman*
PAUL KNIGHT
HOWARD O. DEAY
C. L. METCALF
W. B. HERMS

PETITIONS

Section of Teaching

We, the undersigned members of The American Association of Economic Entomologists, hereby petition the executive committee of our Association to give us permission to create a special section in the Association to be known as the Teaching Section of The American Association of Economic Entomologists. We desire to create this section during the 1938 meetings at Richmond.

(This petition, signed by 74 members, was presented at the first Executive Committee meeting, reported favorably and confirmed at the final business session.)

Florida Entomological Society

At its annual meeting held December 2 and 3, 1938, the Florida Entomological Society voted to petition the American Association of Economic Entomologists for affiliate membership in that organization.

The objectives of the Florida Entomological Society are very similar to those of the American Association of Economic Entomologists as is indicated in Article 1, Section 2 of its Constitution, which is as follows: "The objectives of the society shall be: (1) to promote the study of entomology; (2) to encourage research relative to insects and related arthropods in Florida; (3) to distribute widely knowledge pertaining to insects; (4) to publish the *Florida Entomologist*."

The Florida Entomological Society was formed on January 5, 1916, when 11 men interested in entomology met at the University of Florida in Gainesville. The society has had a continuous existence since its organization, and it has grown greatly with the passing of the years. Included among its membership are such noted entomologists as H. T. Fernald, Herbert Osborn, Wilmon Newell and W. S. Batchley. A list of the members of the society is appended hereto.

In June, 1917, the society began the publication of a journal which was first known as the *Florida Buggist*. The name was changed to its present form, the *Florida Entomologist*, with the first number of Volume IV in 1920. The *Florida Entomologist* is issued quarterly and has been published continuously since its beginning. It is now in its twenty-first volume.

On behalf of the membership of the society we hereby apply to the executive Committee of the American Association of Economic Entomologists for affiliate membership in that organization for the Florida Entomological Society. We await your pleasure and trust that this petition may be received with favor.

J. H. MONTGOMERY, *President*
A. N. TISSOT, *Secretary*

(This petition, presented at the first Executive Committee meeting, was accepted, referred to the

Association and confirmed at the final business session.)

Newell Entomological Society

The membership of the Newell Entomological Society voted at its regular bi-monthly meeting on November 24, 1938, to instruct the executive committee of this society to petition the American Association of Economic Entomologists for affiliate society privileges. We, the executive committee, do hereby respectfully request that the Newell Entomological Society be granted such affiliate privileges.

The objectives of the Newell Entomological Society are very similar to those of the American Association of Economic Entomologists. They are as follows: (1) To promote the study of entomology; (2) To encourage graduate and student research; (3) To distribute widely information dealing with all phases of entomology; (4) To sponsor the Florida Entomological Conference for all professional and student entomologists; (5) To foster the spirit of cooperation among all groups engaged in entomological work; (6) To publish a bi-annual journal dealing with problems of an entomological character which are of great importance to southern agriculture.

The Newell Entomological Society was organized in September, 1934, and the installation exercises were held in February, 1935. The society was named in honor of Dr. Wilmon Newell, provost of agriculture at the University of Florida. Dr. Newell is a Past-President of the American Association of Economic Entomologists.

The membership of the society is of three types. These are undergraduate, graduate and honorary. All entomological graduates of the University of Florida are members of the society and maintain an active interest in its activities. The activities of this society are centered in the State of Florida, but many of the graduate members are employed in states other than Florida.

Respectfully submitted,
THE NEWELL ENTOMOLOGICAL SOCIETY
JAMES TOFFALETI, *President*
RAIFORD BRANCH, *Vice-President*
JACK C. RUSSELL, *Secretary*
HENRY S. CHUBB, *Treasurer*
JOHN T. CREIGHTON

(This petition, presented at the first Executive Committee meeting, was accepted, referred to the Association and confirmed at the final business session.)

REPORT OF THE BOARD OF TRUSTEES OF PERMANENT FUND

The meeting of the Board of Trustees was held on Thursday evening, December 29, with all members present except Dr. P. J. Chapman. The question of the creation of a custodian account occupied the principal portion of the session, and it was finally voted to continue under the same plan as at present. After consideration of the status of the funds, it was ordered that $7,500 be invested in U. S. Savings Bonds at a par value of $10,000, the funds for this to be withdrawn from the Prince Georges Bank and Trust Company of Hyattsville, Maryland, as this bank pays a lower rate of interest than the Massachusetts bank. Previously the Executive Committee had authorized the transfer of $1,000 from Association funds to the Permanent Fund. The Auditor's report carrying a detailed statement of the Permanent Fund is published elsewhere.

—ERNEST N. CORY, *Chairman*

(The action of the Executive Committee in making the transfer and the action of the Trustees were approved by the general session.)

REPORT OF THE MEMBERSHIP COMMITTEE

During the year ending December 28, 1938, your committee is obliged to record the deaths of eight members:

H. A. Ballou
P. A. Glenn
N. T. Kidder
H. E. McMillan
W. E. Rumsey
George A. Smith
Frederick V. Theobold
A. C. Fleury

Fourteen resignations have been received and accepted.

Dues were remitted for one member by action of the Executive Committee.

Ninety-four applications for membership were received and approved.

—A. F. SATTERTHWAIT, *Chairman*
W. P. FLINT

(It was moved, seconded and carried that the report of the Membership Committee be accepted.)

Names of Persons Elected to Membership, Fifty-First Annual Meeting

C. C. Alexander, Dean Asquith, Irwin J. Becnel, Herald C. Bennion, William E. Bickley, Jr., John T. Bigham, R. J. Bishop, N. D. Blackburn, J. F. Bock, Gilbert T. Bottger, Arthur L. Brody, R. C. Bushland, John R. Clark, W. K. Clore, M. M. Cole, H. H. Crowell, Wayne P. Dean, Paul DeBach, H. Rodney Dodge, Philip B. Dowden, G. G. Dustan.

W. D. Edwards, Herman Erhart, Stephen S. Easter, Richard W. Fay, George R. Ferguson, Frank W. Fisk, Martha Harriet Foster, Leo R. Gardner, John H. Girardeau, Jr., K. W. Gray, Olyn T. Guice, Jr., Quinton A. Hare, William J. Haude, R. C. Heslop, L. A. Hetrick, Paul B. Huff, William P. Hunter, Fred B. Jacobson, W. S. James, Ray L. James, H. E. Jennings, John A. Kedzior, J. P. Kislanko, Kenneth L. Knight, Walter M. Kulash.

G. H. Law, Fred R. Lewis, K. S. Littig, Arnold Mallis, Fred W. Mally, Luis F. Martorell, A. E. McCollom, J. M McGough, Kenneth D. McLeod, Norman E. Miller, Lester J. Mills, Robert T. Mitchell, Earl J. Moran, O. A. Nelson, J. E. Neville, Leland B. Norton, H. L. Parten, Donald F. Patterson, N. A. Patterson, Roger L. Pierpont, H. N. Pollard, George E. Powers, John C. Pritchett

Harry B. Ramsey, Claude A. Richards, Louis A. Riehl, Paul T. Riherd, Arthur E. Ritcher, H G. I. Sameth, J. Edwin Sameth, Pope C. Sapp, Herbert F. Schoof, Joe Schuh, Edward H. Smith, E. I. Smith, Louis A. Spain, Lester L. Spessard, Heber F.

Thornley, Joseph R. Tremble, Henry H. True, C. R. Twinn, Edgar J. Udine, J. Paul Vinzant, Thomas C. Watkins, Willis W. Webster, Ellis Westlake, Joe H. Wilkins, E. D. Witman.

REPORT OF THE RESOLUTIONS COMMITTEE

Resolved, That the thanks of this association be extended to W. D. Reed, W. J. Schoene, P. D. Sanders, G. T. French, H. G. Walker and J. W. Bailey, the local committee, for their efficient planning and excellent arrangements in connection with this, the Fifty-First Meeting of the Association; and that we express our grateful appreciation to the city and state officials, citizens, organizations, institutions and industries of Richmond for their most unusual cooperation and courtesy.

Resolved, That this Association extend its thanks to the officers and members of the Entomological Society of America and of the Ecological Society of America for their participation in the splendid joint symposium on insect populations.

Resolved, That the thanks of this Association be extended to Professor C. T. Brues for the delightful and thoughtful address given at the joint dinner with the membership of the Entomological Society of America.

Resolved, That the thanks of this Association be extended to the management of the John Marshall Hotel of Richmond for the accommodations and for the courtesies extended to our officers and members during our meeting.

Resolved, That in view of the interest shown in the instructive and inspirational exhibit of the U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine, such exhibits by appropriate entomological agencies be solicited as features of future meetings of our Association.

Resolved, That since grasslands constitute the largest vegetative unit in the northern Great Plains region, and since original stands of native grasses are fast disappearing and are therefore seldom available to research and teaching agencies, and since extensive insect outbreaks in this region have created insect problems of national economic importance, we, the American Association of Economic Entomologists, indorse the action taken by the Committee on the Ecology of Grasslands of the National Research Council in its efforts to secure the creation of a Great Plains National Monument, which will preserve a large area of native grassland solely for instructional, research and recreational purposes; and that we commend the National Park Service for its efforts in this direction and urge that these efforts be continued.

—HARRY S. SMITH, *Chairman*
P. N. ANNAND
C. O. EDDY

(It was moved, seconded and carried that the report of the Resolutions Committee be accepted.)

REPORT OF THE PUBLICATIONS COMMITTEE, JOURNAL OF ECONOMIC ENTOMOLOGY

The Publications Committee met twice during the Fifty-First Meeting of the Association and discussed matters pertaining to the JOURNAL OF ECONOMIC ENTOMOLOGY, the official publication.

It was moved and carried that an author, or authors, be allowed six pages gratis for any single paper published in the JOURNAL, and that a charge of $6.00 per page or fraction thereof be made for all pages in excess of six.

This action was taken in order to clarify any misunderstanding which might arise because of the recent increase in the page size of the JOURNAL.

It was moved and carried that the names of the following be submitted to the Nominating Committee to serve during the year 1939:

T. H. Frison, Editor
H. B. Weiss, Associate Editor
E. P. Felt, Honorary Editor
E. N. Cory, Business Manager

It was moved and carried that the committee approve the arrangement made by the Editor with the Eastern Branch for the publication of the papers of the latter. This arrangement gives the Eastern Branch space in the JOURNAL equivalent to the pages granted before the change in page size.

It was moved and carried that the report of the Editor be accepted.

It was moved and carried to submit to the Executive Committee for its consideration the suggestion that the Business Manager be authorized to extend the advertising matter in the JOURNAL.

This committee suggests the following names of men to serve informally to aid the Business Manager of the JOURNAL in securing advertising for the year 1939: F. L. Campbell, Roy Campbell, J. J. Davis, C. O. Eddy, G. F. MacLeod, V. I. Safro.

It was moved and carried to extend to T. H. Frison the appreciation of the Committee for his excellent service as Editor of the JOURNAL.

—J. S. HOUSER, *Acting Chairman*
F. L. CAMPBELL
R. T. COTTON for R. C. SMITH
H. G. CRAWFORD
R. B. FRIEND
DON C. MOTE for E. J. NEWCOMER

(The above report was read by Don C. Mote as Mr. Houser had to leave the meeting. The report was approved.)

REPORT OF THE NOMINATING COMMITTEE

The Nominating Committee presented the following names:

President: E. R. Sasscer
First Vice-President: C. H. Richardson
Secretary-Treasurer: Ernest N. Cory
Member of Executive Committee: Harry S. Smith
Committee on Common Names of Insects:
K. M. King. Term expires 1941
D. M. DeLong. Term expires 1941
Committee on Membership: (Through an error in the JOURNAL, A. F. Satterthwait is listed with a term expiring in 1938 and W. P. Flint in 1939, when the reverse is true. R. L. Webster is nominated to succeed W. P. Flint with a term ending in 1941.)
Publications Committee, JOURNAL OF ECONOMIC ENTOMOLOGY:
J. S. Houser. Term expires 1943
Roger B. Friend. Term expires 1943
E. F. Phillips. Term expires 1943
Officers of the JOURNAL Recommended by the Publications Committee:
T. H. Frison, Editor
H. B. Weiss, Associate Editor

Ernest N. Cory, Business Manager
E. P. Felt, Honorary Editor
Joint Committee on Insect Collections: E. C. Van Dyke. Term expires 1941
Program Committee: D. L. Van Dine. Term expires 1941
Committee on Codling Moth:
W. S. Hough. Term expires 1941
W. A. Ross. Term expires 1941
Committee on Insecticide Terminology: R. H. Robinson. Term expires 1943
Joint Committee on Promotion of Official Entomology: T. J. Headlee. Term expires 1941
Committee on Popular Entomological Education: J. A. Hyslop. Term expires 1941
Committee on Cooperation with Pest Control Operators: W. P. Flint. Term expires 1941
Committee on Relation of Entomology to Conservation: T. H. Frison. Term expires 1941
Board of Trustees for Permanent Fund: A. F. Burgess. Term expires 1941
Trustee, Crop Protection Institute: W. C. O'Kane. Term expires 1941
Representatives on Council of Union of American Biological Societies:
P. N. Annand
Charles E. Palm
Representative on Board of Trustees of Tropical Plant Research Foundation: Herbert Osborn
Representative to National Research Council: (S. A. Rohwer, appointed during 1938 to succeed P. N. Annand, resigned, will serve until June, 1940. His successor should be elected at the 1939 meeting.)
Councilor for the American Association for the Advancement of Science: L. A. Stearns. Term expires 1940

Respectfully submitted:
CLAY LYLE, *Chairman*
L. S. MCLAINE
B. A. PORTER

(The officers named by the Nominating Committee were unanimously elected.)

DISCUSSION FROM THE FLOOR

Past-Presidents Osborn and Strong were asked to present the new President.

President Davis: It is a pleasure to greet you, and I wish to congratulate you and hope you will have the same cooperation from the members and officers that I have received in the past year.

Mr. Sasscer: I want to express my appreciation for this honor and say that I will do all I can to work for the Association.

Mr. Hyslop: I would like to know whether or not the expenses of the President for attendance at Branch meetings is paid by the Association.

President Davis: That has not been done in the past.

Mr. Hyslop: I would like to present a motion that expenses of the President to Branch meetings be paid by the Association.

Mr. Strong: I second that motion. I feel that this is a good time to do it. The Association is in good financial standing, and I think no money is better spent than to pay expenses to Branch meetings.

Dr. Cory: The funds are ample to take care of these expenses. I would like to add that I think, since our present president has attended all of the Branch meetings, from the Pacific to the East and to Canada, and done so out of his own pocket, that this motion should be made retroactive for 1938.

(Mr. Strong seconded this, and it was made an amendment to the motion.)

President Davis: I do think it is desirable in the future to pay traveling expenses. I have enjoyed the Branch meetings and believe it is good for the Association to have the President attend them.

(The motion as amended was carried.)

President Davis: The next item is the time and place of the next annual meeting.

Mr. Strong: It seems to me that now might be an appropriate time for the entomological groups to figure out a program of their own for meeting places. We have gone along pretty well with the American Association for the Advancement of Science, but we have 1,150 members in good standing in this Association, and have 94 new members, an organization now of 1,250 members. I do not suppose there is a group in the American Association for the Advancement of Science that has any larger number than that, or a group that is any more important to the AAAS and to science in the United States. We expect people from the Pacific Coast and from the South to attend our meetings, and they do pretty well. We expect them to keep up with the JOURNAL, their dues, etc., and yet they have to be satisfied for their meetings with Branch meetings. Now I grant that Branch meetings are well worth while, but it seems to me that, if this organization is formed for entomologists, we should take this matter into consideration and meet in the South and in the West. Now if the AAAS has just two meetings on the docket, 1939 and 1940, and they expect to meet in Philadelphia in 1940, when we have just been to Atlantic City and to Richmond, it seems to me that the Executive Committee should submit a plan at Columbus for a 5 or 10 year period and select meeting places from the standpoint of entomology and entomologists and not from the standpoint of astronomy or agronomy. If you attend the entomological meetings, you don't have time to go to other meetings.

I move that the Executive Committee be instructed to draw up a plan of 5 or 10 years for meeting places and take the entomological meetings to places where they will do the most good for entomology and entomologists.

(This motion was seconded.)

Dr. Smith: I wonder if there is any possibility of modifying the time of meeting so that those who wish to attend the AAAS can also do that. I understand why meetings are held at this time, but wouldn't some other time be satisfactory so that those who want to attend both the AAAS and the entomological meetings can do so? I move the Executive Committee consider that.

Dr. Cory: I believe it is absolutely essential that we set up a schedule for at least 5 or 10 years, and if in that period we can coincide with the AAAS well and good; but, if we can't, we should consider the primary needs of the entomologists first.

(Motion carried.)

President Davis: I believe we should now fix the time and place for the 1939 meeting.

Mr. Strong: I move the time and place be left to the Executive Committee to fix. (Seconded and carried.)*

* At the meeting of the Executive Committee following adjournment, Columbus was selected as the place for the next meeting and Neale F. Howard was selected as the local chairman. Dr. Howard has since accepted the assignment.

President Davis: Before adjourning I want to express again my appreciation of the very great cooperation of all the members and officers and my welcome at all the various Branch meetings, and to thank the local committee for its part in making this meeting a success.

REPORT OF THE SECTION IN APICULTURE

The Section in Apiculture met at 9:30 a.m., December 28, in the Roof Garden, John Marshall Hotel, Richmond, Va. In the absence of J. M. Robinson, Chairman, M. C. Tanquary was selected Chairman for this meeting. Six of the nine papers listed on the program and three unlisted ones were presented. Three papers were read by title only due to the absence of the authors.

At the conclusion of the discussions, the nominating committee consisting of G. M. Bentley, George Rea and E. L. Chambers submitted its report, which resulted in the election of the following officers for the ensuing year: W. E. Dunham, Chairman, and W. A. Price, Secretary.

—W. A. PRICE, *Secretary*

REPORT OF THE SECTION OF EXTENSION

The tenth annual meeting of the Section of Extension met with the parent Association in the John Marshall Hotel in Richmond, Va., 7:30 P.M., December 29, under the chairmanship of Dr. W. E. Blauvelt, Ithaca, N. Y. Between 60 and 70 entomologists interested in the extension phases of the work were present. The program was built around the relation between extension entomology and classroom teaching of entomology, large insect control programs, research entomology, commercial entomology, retail insecticide trade, and other extension agencies. A special paper, "The Logical Extension Approach in the Meeting of Insect Problems," was presented by H. W. Hochbaum in charge of Subject-Matter Specialists, Extension Service, U. S. Department of Agriculture.

George D. Jones of Missouri was elected chairman and J. O. Pepper of Pennsylvania was elected secretary.

—W. C. NETTLES, *Secretary*

REPORT OF THE SECTION OF PLANT QUARANTINE AND INSPECTION

The meeting of the Section of Plant Quarantine and Inspection was called to order at approximately 9:15 a.m., December 29, 1938, in the John Marshall Hotel, Richmond, Va., by the Chairman, E. L. Chambers. At the morning session papers were presented by Dr. L. A. Strong, Dr. R. P. White, W. C. Kendall, N. T. Wentzel, Milledge Murphey, Jr., Dr. J. T. Creighton and E. L. Chambers. All papers, except that by Dr. Creighton, related to plant quarantine and inspection activities. Dr. Creighton's paper related to the white-fringed beetle.

At the request of those in attendance, the papers relating to quarantine and inspection were mimeographed, and copies have been distributed to plant quarantine officials, nurserymen and others interested in the subject.

The afternoon meeting was held jointly with the phytopathologists, and subjects of mutual interest to both groups were discussed.

At the close of the joint session a short business meeting was held. The Nomination Committee, consisting of Dr. S. B. Fracker, E. S. Rex and T. L. Aamodt, proposed the nomination of G. T. French as Chairman and R. A. Sheals as Secretary. The report was unanimously approved.

The Resolutions Committee, consisting of A. F. Burgess, Roy G. Richmond and Dr. Clay Lyle, submitted the following resolutions, which were unanimously adopted:

1. The thanks of the Section of Plant Quarantine and Inspection are extended to the officers for the interesting and timely program that has been prepared for this meeting and to the speakers who contributed to the program, especially to those who are not members of the section, for the constructive suggestions that have been made concerning the opportunities for improvement and simplification of means whereby the enforcement of necessary restrictions can be accomplished.

The Section of Plant Quarantine and Inspection further urges that the Regional and National Plant Boards continue to give thoughtful consideration to the problems of simplifying inspection and certification procedure in order to facilitate the movement of plants and plant materials and at the same time safeguard against the spread of plant pests.

2. In view of the importance of the papers presented at the morning meeting, it is recommended that the officers of the section be authorized and instructed to make the necessary arrangements for printing, or mimeographing, and distributing these papers at an early date. (Action taken as directed.)

3. WHEREAS, This group has learned with regret of the recent untimely death of Arthur C. Fleury of California, and

WHEREAS, Plant quarantine and inspection activities owe a debt of appreciation to Mr. Fleury for his valuable contributions to plant protective work, now, therefore, be it

Resolved, That the section herewith expresses such appreciation and regret, and, further, instructs the Secretary to communicate accordingly with Mrs. Fleury and family and the Director of Agriculture of the State of California. (Communications were sent as directed.)

Approximately 75 persons attended the section meeting as evidenced by registration cards.

—R. A. SHEALS, *Secretary*

OFFICIAL ROSTER

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Organized 1889; Incorporated December 29, 1913

OFFICERS, 1939

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W. E. Dunham, Columbus, Ohio. (Section of Apiculture)
George D. Jones, Columbia, Mo. (Section of Extension)
John T. Creighton, Gainesville, Fla. (Section of Teaching)

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O. I. Snapp, Fort Valley, Ga. (Cotton States Branch)
H. B. Weiss, Trenton, N. J. (Eastern Branch)
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R. A. Sheals, Washington, D. C. (Section of Plant Quarantine and Inspection)
W. A. Price, Lexington, Ky. (Section of Apiculture)
J. O. Pepper, State College, Pa. (Section of Extension)

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John T. Creighton, *Adviser*

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Executive Committee

E. R. Sasscer, Washington, D. C., *Chairman, Ex officio.*
Ernest N. Cory, College Park, Md. *Ex officio.*
A. F. Burgess, Greenfield, Mass. Term expires 1939.
F. C. Bishopp, Washington, D. C. Term expires 1939.
Clay Lyle, State College, Miss. Term expires 1940.
J. J. Davis, Lafayette, Ind. Term expires 1940.
Harry S. Smith, Riverside, Calif. Term expires 1941.

Committee on Common Names of Insects

J. A. Hyslop, Washington, D. C., *Chairman.* Term expires 1939.
R. B. Friend, New Haven, Conn. Term expires 1939.
T. E. Snyder, New Orleans, La. Term expires 1940.
Claude Wakeland, Moscow, Idaho. Term expires 1940.
K. M. King, Saskatoon, Sask., Can. Term expires 1941.
D. M. DeLong, Columbus, Ohio. Term expires 1941.

Committee on Membership

A. F. Satterthwait, Urbana, Ill., *Chairman.* Term expires 1939.
C. L. Metcalf, Urbana, Ill. Term expires 1940.
R. L. Webster, Pullman, Wash. Term expires 1941.

Publications Committee, Journal of Economic Entomology

W. B. Herms, Berkeley, Calif., *Chairman.* Term expires 1940.
H. G. Crawford, Ottawa, Can. Term expires 1939.
Roger C. Smith, Manhattan, Kan. Term expires 1939.
S. A. Rohwer, Washington, D. C. Term expires 1940.
F. L. Campbell, Columbus, Ohio. Term expires 1941.
F. L. Thomas, College Station, Tex. Term expires 1941.
R. R. Parker, Hamilton, Mont. Term expires 1942.
E. J. Newcomer, Yakima, Wash. Term expires 1942.
J. S. Houser, Wooster, Ohio. Term expires 1943.
Roger B. Friend, New Haven, Conn. Term expires 1943.
E. F. Phillips, Ithaca, N. Y. Term expires 1943.

Joint Committee on Insect Collections

C. F. W. MUESEBECK, Washington, D. C., *Chairman.* Term expires 1939.
JOSEF KNULL, Columbus, Ohio. Term expires 1939.
T. H. FRISON, Urbana, Ill. Term expires 1939.
R. H. BEAMER, Lawrence, Kansas. Term expires 1940.
E. C. VAN DYKE, Berkeley, Calif. Term expires 1941.
FRANKLIN SHERMAN, Clemson College, S. C. Term expires 1940.

Program Committee

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D. L. VAN DINE, Washington, D. C. Term expires 1941.
GEORGE A. DEAN, Manhattan, Kans. Term expires 1940.

Committee on Codling Moth

B. A. PORTER, Washington, D. C., *Chairman.* Term expires 1940.
R. L. WEBSTER, Pullman, Wash. Term expires 1939.
H. N. WORTHLEY, State College, Pa. Term expires 1939.
C. R. CUTRIGHT, Wooster, Ohio. Term expires 1940.
W. S. HOUGH, Winchester, Va. Term expires 1941.
W. A. ROSS, Vineland Station, Ont., Can. Term expires 1941.

Committee on Insecticide Terminology

HARRY F. DIETZ, Wilmington, Del., *Chairman.* Term expires 1941.
WILLIAM MOORE, New York, N. Y. Term expires 1939.
C. M. SMITH, Washington, D. C. Term expires 1940.
F. L. CAMPBELL, Columbus, Ohio. Term expires 1942.
R. H. ROBINSON, Corvallis, Ore. Term expires 1943.

Joint Committee on the Promotion of Official Entomology

J. J. DAVIS, Lafayette, Ind., Chairman. Term expires 1939.
T. J. HEADLEE, New Brunswick, N. J. Term expires 1941.
GEORGE A. DEAN, Manhattan, Kans. Term expires 1940.

Committee on Popular Entomological Education

C. J. DRAKE, Ames, Iowa, *Chairman.* Term expires 1939.
R. R. REPPERT, College Station, Tex. Term expires 1940.
J. A. HYSLOP, Washington, D. C. Term expires 1941.

Committee on Cooperation with Pest Control Operators

J. J. DAVIS, Lafayette, Ind., *Chairman.* Term expires 1940.
E. A. BACK, Washington, D. C. Term expires 1939.
W. P. FLINT, Urbana, Ill. Term expires 1941.

Committee on Relation of Entomology to Conservation

F. C. BISHOPP, Washington, D. C., *Chairman.* Term expires 1940.
SAMUEL A. GRAHAM, Ann Arbor, Mich. Term expires 1939.
T. H. FRISON, Urbana, Ill. Term expires 1941.

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CHARLES E. PALM, Ithaca, N. Y. Term expires 1939.

Representative on Board of Trustees of Tropical Plant Research Foundation

HERBERT OSBORN, Columbus, Ohio. Term expires 1939.

Representatives to National Research Council

S. A. ROHWER, Washington, D. C. Term expires June, 1940.

Z. P. METCALF, West Raleigh, N. C. (Alternate) Term expires 1940.

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JAMES I. HAMBLETON, Beltsville, Md. Term expires 1939.

L. A. STEARNS, Newark, Del. Term expires 1940.

JOURNAL OF ECONOMIC ENTOMOLOGY

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Bailey, Stanley F., University Farm, Davis, Calif.
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Baker, Arthur C., Laboratory of Entomology, Calzada Tacuba 295, Colonia Anahuac, Mexico, D. F.
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Barber, H. S., U. S. National Museum, Washington, D. C.**
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Bartlett, Irene L., Room 375, U. S. National Museum, Washington, D. C.
Bartlett, Kenneth A., Ag. Exp. Station, Mayaguez, P. R.
Bartlett, O. C., 2211 West Washington St., Phoenix, Ariz.
Bartley, H. N., Fourth Floor, Custom House, Boston, Mass.
Basinger, A. J., Citrus Experiment Station, Riverside, Calif.
Batchelder, C. H., 91 Wakefield St., Hamden, Conn.**
Baumhofer, L. G., 6020 N. 20th St., Arlington, Va.**
Beal, James A., Forest Insect Laboratory, Fort Collins, Colo.
Becker, G. G., B.E.P.Q., Washington, D. C.
Becker, William B., Fernald Hall, Massachusetts State College, Amherst, Mass.
Beckwith, Charles S., Cranberry Experiment Station, Pemberton, N. J.
Becnel, I. J , Lucy, La.
Bedard, Wm. Delles, Forest Insect Field Station, Coeur d'Alene, Idaho.
Bedford, Theodore, Wellcome Research Laboratory, Khartoum, Sudan.
Ben-Amotz, Yehiam, P.O. Box 9, c/o The Shell Co. of Palestine, Jaffa, Palestine.
Bennett, William H., Dept. of Forest Ent., Syracuse University, Syracuse, N. Y.
Bennion, H. C., U.A.C., Logan, Utah.
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